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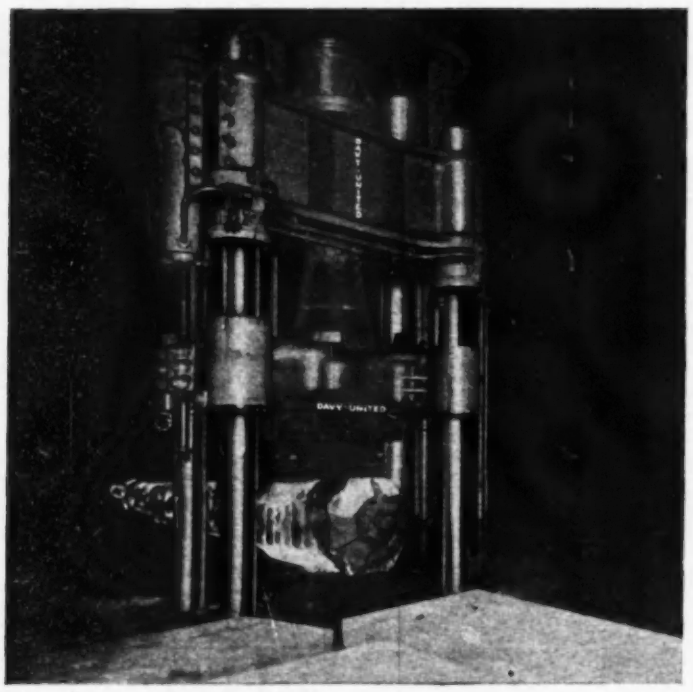

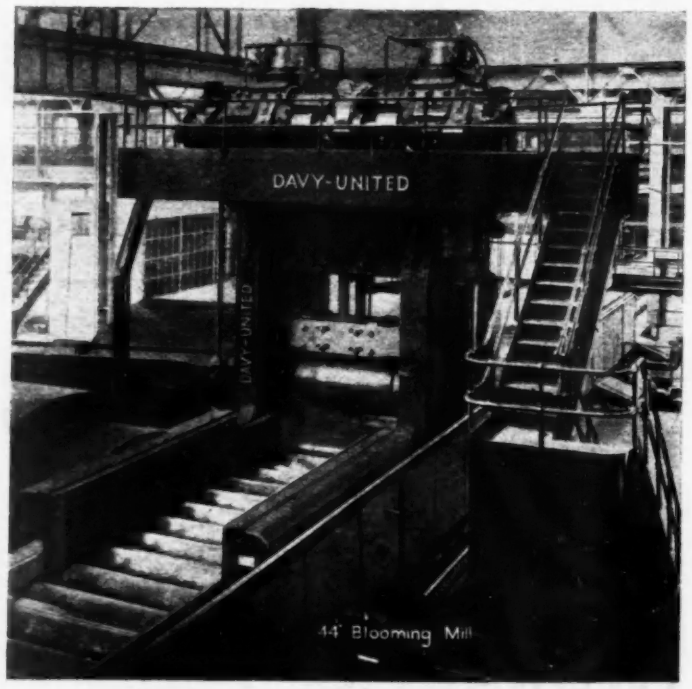

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THE STORSTROM AND MASNEDSUND BRIDGES, DENMARK.

(*Concluded from page* 6.)

CONTINUING our description of the Storstrom and Masnedsund Bridges, which form important railway and road links in Denmark, attention may first be called to Figs. 22 and 23. These give a good idea of the construction of the piers of the Storstrom Bridge, details of which were published on page 4 of our issue of January 5.

Each of the three navigation openings, the appearance of which will be clear from Figs. 17 and 18, Plate IV, are spanned by tied stiffened arches of through construction. These arches are shown in course of erection in Figs. 20 and 21, Plate IV. The stiffening is in the form of parallel plate girders at deck level. The deck and polygonal arch ribs are connected by vertical hangers and the main girders are spaced 39 ft. 4½ in. from centre to centre. The details of this construction were given in Figs. 8 to 11, Plate IV, in the issue of ENGINEERING just referred to, and it may be noted that the main dimensions on Fig. 8 show the geometric distances from the arch-rib intersections to the neutral axis of the stiffening girders. The arch ribs consist of two built-up channel sections with flanges turned outwards. These ribs are connected by a solid upper flange plate and by a single angle lacing. Owing to the fact that the road and railway tracks lie between the stiffening girders, it was impossible to obtain equal loading on both girders. The sections of the railway-side girder are, therefore, uniformly less than those on the road side. The arch ribs are connected by a system of double diagonal lateral bracing without cross-members. These are extended as far as the roadway clearance will permit. All the lateral members consist of rolled-steel joists. Portal bracing is provided on the vertical hangers at the ends of the lateral system to transfer any lateral force from the ribs to the deck. The longest hangers consist of a pair of battened channels, the shorter hangers being built up of I-section.

The stiffening girders, which also form the arch ties, are designed as plate girders 12 ft. 0½ in. deep. The intersection point with the axis of the arch rib is situated 4 ft. 3⅜ in. above the centre line of the stiffening girder to assist in equalising the stresses on the girder flanges. A full system of lower lateral bracing of joist sections is provided. This is attached to the bottom flange of the stiffening girder. The end cross-girders are designed to resist the effect of tractive forces set up by trains crossing the bridge. The end bearings are of the cast-steel spherical-rocker type. The expansion bearings are mounted on pairs of cast-steel segmental rollers, 28 in. in diameter. Provision is made in the design of the end cross girders for lifting the spans on jacks in the event of any settlement of the piers. The deck steelwork is of conventional cross-girder and stringer construction. The footway is carried on cantilever brackets outside the main girder. The railway deck is of open timber construction, and is laid directly on the stringers, alternate sleepers being cleated to the flanges. Guard rails are employed for the full length of the navigation spans. The road and footway decks are similar to those on the approaches. Joints are provided in the deck and stringers at both ends and at the centre of each span. The main expansion joints at one end of each span, and the other joints in the deck, are of similar type to those on the approaches. A painting traveller is provided below the deck of each span and there are inspection walk-ways below the arch ribs.

Commenting on the design of the Storstrom bridge in a paper read before the Institution of Civil Engineers,* Messrs. Maunsell and Pain point out that though the advantage in cost rests with the lattice girder, the plate girder is more pleasing in appearance, especially owing to the disproportionate depth of the lattice spans near the end of the bridge where the height above water level is reduced. The plate girder gains over the lattice girder in freedom from secondary stress and probably possesses a higher load factor. The shallower depth of the plate girder for the same stiffness allows a large headroom below the girders, and the exposed area requiring painting is only about half that of the lattice girder. The type of the design adopted for the three navigation spans harmonises with the outline of the bridge approaches and retains the clean appearance of the plate-girder construction. It was also easier to erect than a lattice-girder construction. The actual weight of steel in the three navigation spans is 3,460 tons, compared with 3,060 tons for a normal through-type braced cantilever design. About 13 per cent. more steel was, therefore, required.

Without the use of high-tensile steel, many of the plate-girder details, such as flange splices, would have been extremely clumsy, while the rivet grips would have been excessive. High-tensile steel rivets were employed for the connection of all high-tensile steel parts. Both structural and rivet material proved perfectly satisfactory in fabrication and demanded no modification in the normal shop processes. In general, the whole of the arch ribs, hangers, stiffening girders and approach main girders with their stiffeners were of high-tensile steel. All the deck material was of manganese steel, with the exception of the end cross girders of the arches, which were of high-tensile steel. The lateral bracing was of manganese or ordinary mild steel, except for the approach-span portal bracing, which was of high-tensile steel. Ordinary mild steel was only used for packings and for lightly-stressed parts such as handrails and walk-ways. Nevertheless, the usual rules for the minimum thickness of material were rigidly adhered to throughout.

The whole of the steelwork for the Storstrom bridge was rolled and fabricated by Messrs. Dorman, Long and Company, Limited, at Middlesbrough, and was shipped directly to the site, in consignments of about 1,000 tons, in steamships chartered from Mr. W. Robertson, of Glasgow. Chromador high-tensile steel was employed wherever it was economical. The scheme of erection and all special plant and equipment, such as the floating crane described below, were also evolved by Messrs. Dorman, Long and Company's Bridge Department. All the spans were built on a slipway, which was constructed for the purpose on the south shore of the island of Masnedo, near the yards which had been constructed for general works purposes. The building berth was at ground level and was spanned by a goliath crane running on a track parallel with the shore. Before leaving England the girders were riveted up in as large pieces as was consistent with a weight limit of 25 tons and the capacity of the holds of the carrier ships. On arrival, the ships were berthed at a specially constructed reinforced-concrete deep-water jetty and were discharged by means of a 25-ton derrick crane on to rail bogies which took them to a storage ground about 300 yards distant. Smaller pieces of steel were discharged by 5-ton travelling cranes on to a separate storage area. It was thus possible to store a large quantity of steelwork on the site, so providing elasticity between the shop fabrication work in England and the erection programme in Denmark.

After a bridge span had been built complete with its rocker bearings on the building berth, it was jacked up and lowered on to special carriages running upon steel ball-race tracks. These tracks were laid on a pair of low concrete runways which extended from the building berth on shore for a

FIG. 22. NAVIGATION SPAN FROM BELOW.

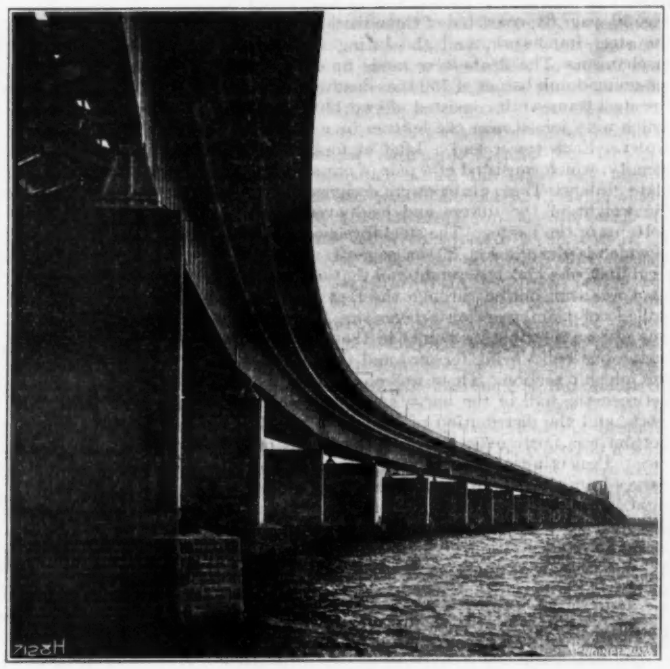


FIG. 23. MASNEDO APPROACH.

* See *Journal of the Institution of Civil Engineers*, vol. 11, page 391 (1939).

distance of 190 ft. into a channel dredged for the reception of the floating crane. The four carriages, each of which was carried on thirty 3-in. steel balls, supported the weight of the bridge spans, which in some cases amounted to nearly 500 tons. The concrete runways were supported on timber-piled foundations. The whole arrangement worked admirably, except for a slight difficulty in getting a material to stand up to the load from the balls. The average load on each ball amounted to 4 tons, but owing to small irregularities in the track and other factors, this load was liable to be considerably exceeded momentarily. The point pressure on the base track was, therefore, rather high. It was found that specially-hardened steel strips tended to crack and spall under the balls, whereas ordinary mild-steel strips tended to form grooves in which the balls ran.

The spans of the Storstrom bridge, which weighed about 500 tons each, were floated out, hoisted to a height of 90 ft. above water level and placed on their bearings by a floating crane. This crane, details of which are given in Figs. 28 and 29, on this page, and of which a photograph is reproduced in Fig. 30, page 64, consisted of three parts: the floats, the steel framework, and the lifting and moving mechanism. The floats were made up of two steel sea-going dumb barges of 750 tons deadweight, while the steel framework consisted of two 140-ft. towers, which were joined near the bottom by a lattice box girder. Each tower had a kind of foot at its extremity, which consisted of a pair of cross-connected plate girders. These girders were designed to spread the weight of the towers and load evenly on the bottoms of the barges. The steel framework, a view of which is given in Fig. 30, on page 64, was a single rigid unit, of which the weight and that of the bridge span was transmitted through the foot girders to a grillage of plain steel joists beneath. This grillage was at two distributing points in the length of the barge, one point being forward and the other aft of the midship section. There was no rigid connection between the hull of the barge and the steel framework, and the distribution of load along the barge bottom was fairly even under all conditions of service. Projecting upwards through the deck of the barges from the forward part of the two girders were rigid steel posts and platform members, which were designed to support the bridge span when it was in the lowered position. This platform formed part of the framework and as it was not connected to the barge decks the dead load, whether at rest or uplifted, could not subject the hulls to any excessive strain.

The two barge hulls were connected near their bows by a steel tie girder above water level, which was designed to withstand any relative distortion. This girder was made as flexible as possible consistent with strength, and its connection to the hulls was distributed over as great an area as was practicable in order to reduce local concentration of stress. Apart from the steel superstructure, it formed the only connection between the two barges. Provided the barges did not have to be navigated in waves of more than 5 ft. from crest to trough, serious stresses from diagonal hogging or sagging were not set up.

The mechanical equipment comprised both lifting and moving mechanism. The lifting mechanism was operated by two steam-driven 25-ton worm-driven main winding winches. In addition, there were six steam winches, most of which were mounted beneath the barge hatchways so as to be out of the way. Each of these winches hauled on a wire-rope mooring, there being one fore and one aft and one breast mooring rope on each side of the equipment. These winches were used to warp the craft out of and into the dock channel and to make fast to the bridge piers on either side when fixing a span. The rough adjustment having been made by means of deck winches, the delicate final movements required to bring the span exactly into position over its bearings were effected by means of hand crab winches fixed on the lifting cradles. There were six of these winches, three operating at one end of the span and three at the other. One of these ropes gave a direct longitudinal pull between the suspended span and a ring bolt fixed on the top of the pier. The other two gave side pulls in either direction and were fastened to the same ring bolt. When lowering a span into position, it was necessary to control simultaneously, the six deck winches, the six cradle winches and the two winding winches. Control was in the hands of a central operator on the floating crane, who was connected by telephone to an engineer on each pier and to a foreman standing aloft on the span between the cradles, who passed orders on to the men working the hand winches. The central operator, being on a staging just above the barges, could pass direct orders by hand signal to the men operating the deck winches and also to those on the main winding winches. The engineers on the piers kept the central operator advised of the exact movement of the span with regard to the two bearings, each on his particular

THE STORSTROM BRIDGE, DENMARK.

Fig. 24.

Fig. 25.

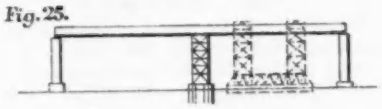


Fig. 26.

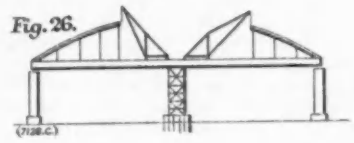


Fig. 27.

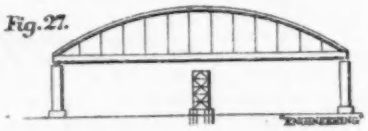


Fig. 28.

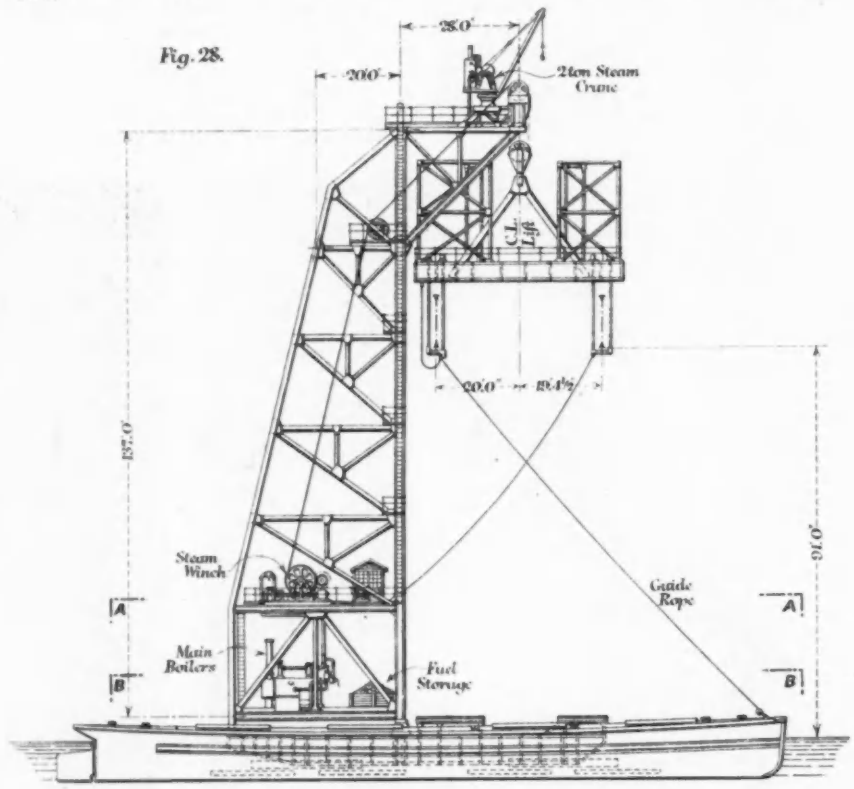
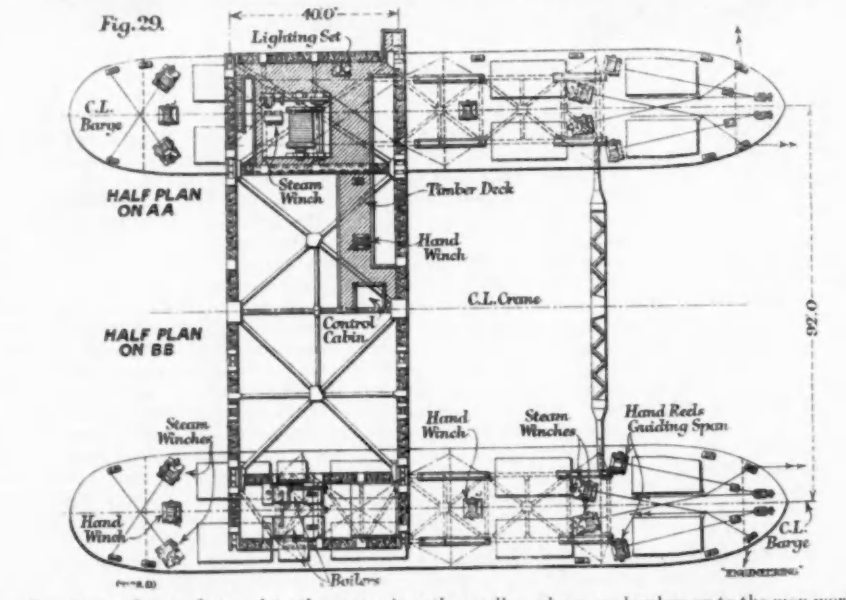


Fig. 29.



pier. The fixed-bearing end of a girder was usually first contacted and the rocker bearing immediately afterwards. The total time taken for the erection of the first span was 12 hours, but when the crews became more adept this was reduced to between four hours and five hours for warping out of the dock, hoisting the span, lowering to the site, setting the span, casting off and returning to dock. Two anchor spans had to be erected before the suspended span between them could be put up, but the operation of floating out, hoisting and placing the spans was very similar in the two cases.

The erection of the three navigation spans had to be carried out by a more complicated method, as the central navigation span weighed 1,520 tons, or about three times the weight the floating crane could lift. To overcome this difficulty, the procedure shown diagrammatically in Figs. 24 to 27, opposite, was adopted. The chord or tie-girder portion was built in two halves in the yard and first one half and then the other was erected by the floating crane. This necessitated providing a temporary support in the middle of the span, as shown in Figs. 31, 32 and 33, on page 64, and as after the two halves had been erected and riveted together they were not strong enough to support their own weight the temporary support had to be left in position until the arch had been built. When the first half of the first navigation span to be erected was ready for floating out, a 20-ton crane was built upon it and floated out, together with the span, as shown in Figs. 32 and 33. After the other half span had been erected and the two had been spliced together, the derrick crane moving on a track on the deck of the span assembled the arch rib members as it rolled forward. This work was commenced at one end of the arch rib under construction and was carried right through until a closure had been effected on to the chord member at the far end. This procedure was adopted as being preferable to commencing the erection at each end of a span and closing the arch rib in the centre.

The temporary support under the middle of the chord member could be raised or lowered by means of hydraulic jacks. In order to splice the ends of the opposing half chord members the centre support had to be lowered about 18 in. below the normal position. After the splice had been made the pedestals were jacked up to a little above normal while the arch rib was being built. The jacks were finally used when the time came to close up and rivet the last joint between the arch rib and the chord member. When the span was completely built, the 20-ton crane was left standing just clear of the end span ready to be run forward on the chord of the adjacent navigation span. The temporary pier support consisted of two parts, the base and the tower. The base was a heavy piled timber platform, constructed of spruce, while the tower was built of spruce capped with oak, the posts being formed of groups of roughly squared, 10 in. by 10 in. logs, and the bracings of round or half logs with the bark on.

Modified constructional methods were used for erecting the spans adjoining the shore at both ends of the bridge, where the floating crane could not be used owing to the shallowness of the water. The principle adopted was to erect the shore span out from the shore and afterwards to traverse it horizontally into position, as shown in Fig. 15, on page 12 of our issue of January 5. For this purpose it was in one case necessary to build on a part of the third span with a temporary rigid connection when making up the shore span, so as to get the necessary length for the traversing operation.

The dovetailing of the steel erection to fit in with the programme of pier construction was carefully planned in advance. It was facilitated by the provision of storage room for five complete bridge spans to stand on the launching slipway. This enabled the building of the spans to proceed steadily at the rate of between two and three complete spans per month from shortly after the start until the finish. After the steel had been delivered at the site it was exposed to the weather in the unpainted state before and during assembly, and after erection for at least 12 months to get rid of the mill scale. The whole of the exposed surface was then cleaned by sand blasting *in situ* until the metal was perfectly cleaned and burnished, whereupon it was sprayed with three coats of paint. A final coat of aluminium paint was applied by hand. The arch rib and hanger members of the navigation-span girders were sand blasted piecemeal in a shed built for that purpose, and the first two coats of paint were then sprayed on immediately. It was found that the sand blast gave a perfectly clean burnished-metal surface upon well-rusted steel surfaces, but it was ineffective in removing mill scale when loosened by rust.

The low-level bridge across the Masnedsund, a view of which appears in Fig. 19, Plate IV, is 728 ft. 4 in. long and consists of five fixed spans, each 103 ft. 4 in. long, with a headroom of 16 ft. 5 in. and a bascule span 93 ft. 2 in. long, giving a clear opening of 82 ft. It is built on four small concrete piers and one larger pier, which house the trunnion, counterweight and bascule operating mechanism. There are also two bridge abutments. Each of the five fixed spans is carried by two simply-supported plate girders, 37 ft. 10¾ in. apart. These girders are 8 ft. 4½ in. deep over angles with ½ in. web plates and are provided with a full system of lower lateral bracing in the plane of the bottom flanges. Cast-steel spherical rocker bearings are provided at both ends of each span, the expansion bearings being carried on a pair of rollers. The deck is of similar construction to that already described for the Storstrom bridge. The bascule span is carried by two main plate girders of similar construction to those used in the fixed spans. Hollow trunnion pins are cantilevered out from the girders and rest on bearings at the front of the pier. Heel extensions of the main girders project across the pier and carry the main driving pinions which operate on cast-steel toothed racks mounted on the back wall of the pier. The operating machinery is mounted in a cabin on the pier and the drive is transmitted by shafting and bevel gearing through the hollow trunnion to the driving pinion. A steel-plated ballast box filled with old rails grouted in position and weighing 560 tons is accommodated between the main girders at the heel of the span.

The main machinery was constructed by Messrs. Sir William Arrol and Company, Limited, Glasgow, and comprises a first-motion unit on one side of the bridge, which is driven by a 70-brake horse-power, 380-volt, three-phase motor, with a 70-brake horse-power, 440-volt, direct-current motor as a stand-by. Emergency hand-operated gear is provided on the other side of the bridge. The power from these units is transmitted to a central longitudinal shaft by spur and bevel gearing. The torque on the rack-pinion shafts is equalised by a differential between them and the longitudinal shaft. The span is designed to be fully-opened against a normal resistance in 75 sec.

The other works include approach embankments to the Storstrom bridge which reach a maximum height of 57 ft. 6 in. and project 1,300 ft. into the sea at the southern end. A total length of 13 km. of new railway was also constructed on both sides of the bridge, while the town of Vordingborg, on the north side, was by-passed by a road consisting of a 21 ft. 6 in. carriage-way flanked by two 5-ft. cycle tracks and two 2-ft. 6-in. footways.

The information given in the above article is based on a paper read before the Institution of Civil Engineers by Messrs. G. A. Maunsell, B.Sc., M.Inst.C.E., and Mr. J. F. Pain, M.C., B.Sc., A.M.Inst.C.E. We have to thank Messrs. Dorman, Long and Company, Limited, for the loan of the drawings and photographs from which our illustrations have been prepared.

THE INSTITUTE OF METALS.—As a war-time measure, the Council of the Institute of Metals has decided that all candidates for membership whose applications are found to be in order, and are received before noon on February 8, will have the privilege of an extra four months' membership. A candidate's next subscription, following his initial payment, will not become due, therefore, until July 1, 1941. The present great activity in the metallurgical and engineering worlds is resulting in a large number of membership applications being received by the Institute of Metals, which is maintaining, and even increasing, its activities, with the exception of those of a social character. The necessary membership application forms can be obtained on application to The Secretary, 4, Grosvenor-gardens, London, S.W.1.

RECENT COURT CASES.—I.

By W. SUMMERFIELD, M.A., B.C.L., LL.B.

Moratorium for Contractors.—The Courts (Emergency Powers) Act, 1939, provides, by Section I, that the leave of the Court must be obtained before a judgment creditor may proceed to execution against the judgment debtor. The Court may refuse such leave, or may grant it subject to such restrictions and conditions as it thinks proper, having regard to the particular facts of each case before it, where the debt arises out of a contract made before September 1, 1939, and the debtor satisfies the Court that he is "unable" immediately to pay by reason of "circumstances directly or indirectly attributable" to the war. The question arises, what precisely is meant by "unable." The problem was considered sufficiently difficult to warrant the summoning of a full Court of Appeal (comprising Sir Wilfrid Greene, the Master of the Rolls, and Lord Justices Slesser, Clauson, MacKinnon, du Parcq and Goddard) to consider it in the case which is reported as *A* v. *B*. The principles are of importance to all creditors and debtors, of course, but are of especial interest to engineering contractors, whose obligations and receipts are apt to be spread out over a considerable period, so that many pre-war contracts will, for some time ahead, be affected by the Act and its "moratorium."

On September 25, 1939, the creditors in this case had obtained judgment against the debtors on bills of exchange which the latter had accepted, but which had been dishonoured. Having obtained judgment, the creditors, on the following day, applied for leave to proceed to execution. The debtors were a limited company whose business involved the making of contracts under which payment to them was spread over considerable periods, and from the outbreak of the war, the volume of their turnover was appreciably reduced. In opposing the application of these creditors for leave to proceed, the chairman of the debtor company put in an affidavit showing that, if they paid them, their other creditors might well be prejudiced and their shareholders would be placed in a serious position. They contended that they were, accordingly, "unable" to pay. The Master of the Rolls observed that "this legislation is new, and the practice to be followed under it has not been settled"; and that, accordingly, the Court would give the debtor company opportunity to file a further and fuller affidavit as to their financial position.

It would seem that the debtor must present a comprehensive statement of his financial position generally and of his assets and liabilities. At the same time, the Court was not prepared to say that, in all cases where a debtor actually has sufficient cash available to pay the particular creditor, he must be deemed "able" to pay him within the meaning of the Act. Where he has other debts to meet, that is a factor to be taken into consideration. "Unable" must be "construed in a reasonable and commonsense way." The Act is not designed for the protection of creditors generally; that is to say, it does not introduce a new form of bankruptcy procedure. The working out of these emergency provisions by their application to concrete cases, as time goes on, will be watched with anxiety by engineering concerns, since the "ability" of contractors and sub-contractors to collect and to pay their debts reacts upon all the links of the chain which binds together the various parties.

Public Works.—The Court of Appeal has dismissed the appeal of the defendants in *Provender Millers (Winchester) Limited* v. *Southampton County Council*. The importance of the case may be gathered from the fact that it occupied the Courts for fourteen days. It arose in this way. The plaintiffs owned and occupied the Wharf Mill, Winchester, situated by the River Itchen. It had been worked by water-power from the river for more than a hundred years. The defendants were the highway authority responsible for maintaining a bridge which carried the roadway over a stream, running parallel with the river. Flood water had been escaping into the highway, and, in 1937, the Council decided to rebuild the existing culvert with the objects of securing an increased measure of support for the road, providing a better outlet for flood water by easing a bend in

the stream near to the culvert, and making a new culvert. The plaintiffs complained that, as a result of these operations, the water flowing to their mill had proved inadequate for their power requirements. Accordingly, they applied for an injunction to restrain the defendants and their agents from doing anything which would have the effect of reducing the flow of water down the river to their mills, and for a mandatory order directing them forthwith to construct all works necessary to restore the flow of water to its pre-1937 condition; also, they claimed damages. Mr. Justice Farwell, before whom the case came originally in the Chancery Division, after hearing a mass of technical engineering evidence for ten days, decided in favour of the plaintiffs. He came to the conclusion that, viewed from the strictly engineering angle, the works carried out by the Council had been executed in a proper manner. Nevertheless, the result had been to produce an increased flow of water in the subsidiary stream and a consequent decrease in the main stream, so that the plaintiffs were deprived of their normal flow from the natural watercourse.

Public and Private Works.—There is a marked difference to be observed in the legal liability attaching to a public authority in such cases as this, as contrasted with that which is imposed upon a private party executing works. If the interference is caused by a private party, the plaintiffs would certainly be entitled to an injunction and possibly, also, to damages; damages could be claimed if it could be shown that the plaintiffs had acquired a right to a flow by long user and that a substantial diminution of that right had been caused.

Where, however, a public authority is concerned, they enjoy a more privileged position, since they have duties which they must discharge in accordance with statute. Accordingly, they are not to be held liable to the complaining party if they can satisfy the Court that they have discharged their statutory duties properly. But they cannot claim to have acted properly if they might have executed the necessary works in some other way which would have avoided inflicting loss or damage upon the complaining party. In other words, the legislature, when it imposes statutory duties upon a public authority, does not sanction their infringing upon private rights further than is absolutely unavoidable.

Mr. Justice Farwell expressed the view that a great deal of expenditure, which might ultimately prove wasteful, might be avoided if, when public authorities were minded to execute works, they advertised their plans before beginning to put them into operation. Any private parties who might suffer in consequence of such works would then have an opportunity of presenting reasonable objections, and of consulting with the authority upon such plans and specifications as might be available. Such co-operation might well result in the production of schemes satisfactory to all concerned, without resort to the Courts. In the Court of Appeal, a good deal of discussion ranged round the question whether the stream affected was a natural or artificial watercourse, but it was held that that question did not affect the ultimate result.

Compensation.—In many cases where the Legislature orders or sanctions public works, it bears expressly in mind the possibility or probability that private interests may be adversely affected thereby and makes provision, accordingly, in the special Act, for assessing and awarding compensation in respect of loss or damage occasioned. Hence, where no such special provision for compensation is made by statute, the Courts will be meticulous in examining into the technical aspects of the works which have been executed, and the alternative methods of proceeding which might have been adopted. This question of compensation was exhaustively considered and emphasised in *Southwark and Vauxhall Water Company* v. *Wandsworth District Board of Works* (1898), 14 T.L.R., 508.

A case in which private interests were adversely affected, but where it was held that no compensation was payable, was *East Fremantle Corporation* v. *Annois* (1902) A.C. 213. There the plaintiff's premises were adversely affected by certain street improvements which had been executed; but the Court held that the statutory powers under which the Corporation acted in this matter had been conferred upon them by a Colonial Act which had been framed in terms sufficiently wide to afford them protection in the circumstances. The particular technical facts of each case presented must be examined by the Court in the light of the particular Act under which the public authority has acted. For although local and private Acts frequently reproduce "model clauses" or provisions in common form it is highly dangerous to take such "as read" before formulating plans for works to be executed for public authorities.

Main Principles.—One of the most important and illuminating of the leading cases on this oft-recurring issue of public duties versus private rights is *Manchester Corporation* v. *Farnworth* (1930) A.C. 171. The defendant Corporation had there constructed an electricity-generating station, pursuant to powers conferred upon them by the Manchester Corporation Act, 1914. The plaintiff farmed in the vicinity of the generating station, and complained of loss resulting to him from the emission of poisonous fumes from its chimneys. He claimed that the Corporation had created a nuisance, and he sought an injunction to restrain it; he asked also for damages. The case went to the House of Lords and resulted in favour of the plaintiff. The public authority, it was held, have imposed upon them the burden of proof; they must show that they have exercised all reasonable care to avoid creating a nuisance by their operations.

Viscount Dunedin laid down the following guiding principles:—(1) "When Parliament has authorised a certain thing to be made or done in a certain place,

COMPRESSION TESTS ON CLAY SOILS.

(For Description see Opposite Page).

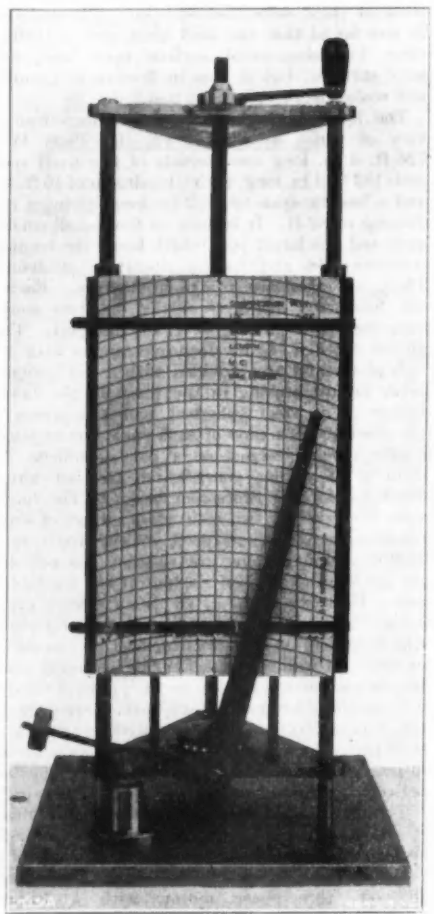


FIG. 1.

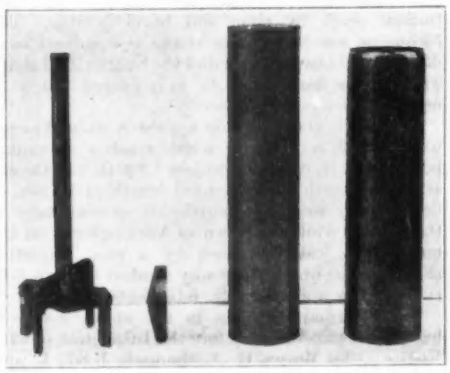


FIG. 3.

Fig. 2.

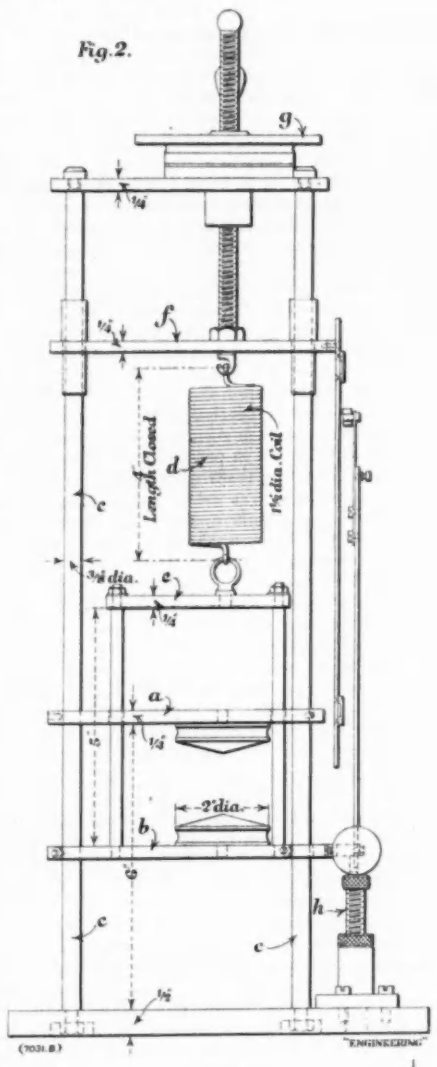
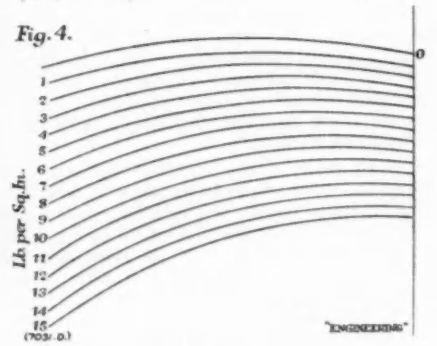


Fig. 4.



COMPRESSION TESTS ON CLAY SOILS.

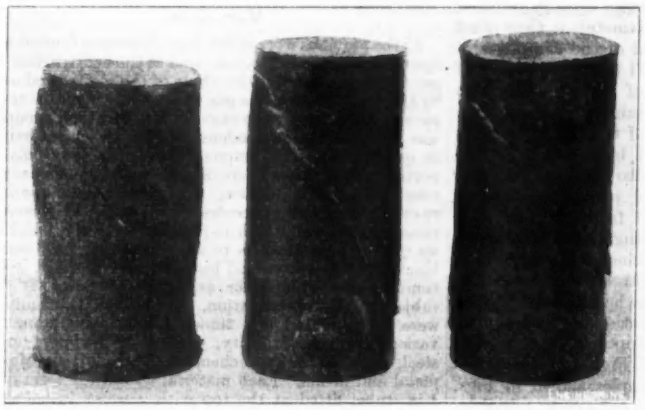


FIG. 5.

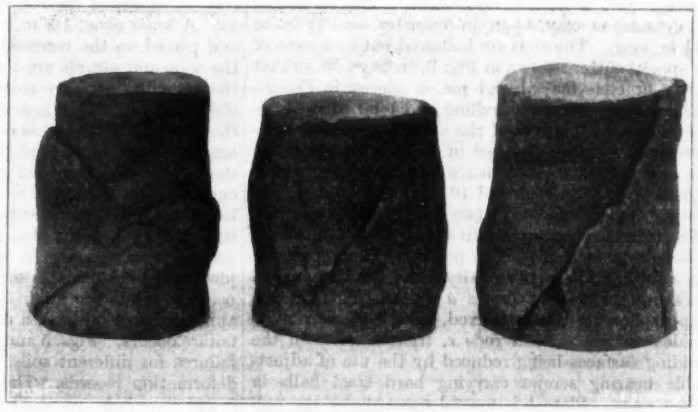
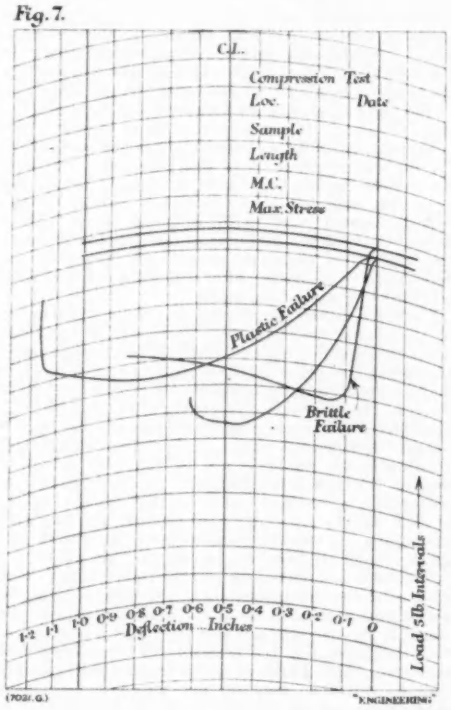


FIG. 6.

Fig. 7.



there can be no action for nuisance caused by the making or doing of that thing if the nuisance is the inevitable result of the making or doing so authorised"; (2) "The onus of proving that the result is inevitable is on those who wish to escape liability for nuisance"; (3) "The criterion of inevitability is not what is theoretically possible, but what is possible according to the state of scientific knowledge at the time"; (4) However, there must also be kept in view "a certain commonsense appreciation, which cannot be rigidly defined, of practical feasibility in view of situation and of expense."

THE INSTITUTION OF CIVIL ENGINEERS.—The 19th annual dinner of the Yorkshire Association of the Institution of Civil Engineers will be held on Thursday, January 25, at the Hotel Metropole, Leeds, at 6.45 for 7 p.m. Further particulars may be obtained from the honorary secretary, Mr. J. H. W. Freeman, "Briarcliffe," Harrogate-road, Alwoodley, Leeds.

REDUCTION IN NUMBER OF ELECTRICITY COMMISSION.—Statutory Order No. 134 of 1939 reduces the number of Electricity Commissioners which are required by subsection 3 of section 1 of the Electricity (Supply) Act, 1919, to be full-time officers from three to two, as from October 16, 1939. The position of Sir Cyril Hurcomb, who was appointed Director-General of the Ministry of Shipping on that date, is thereby legitimised.

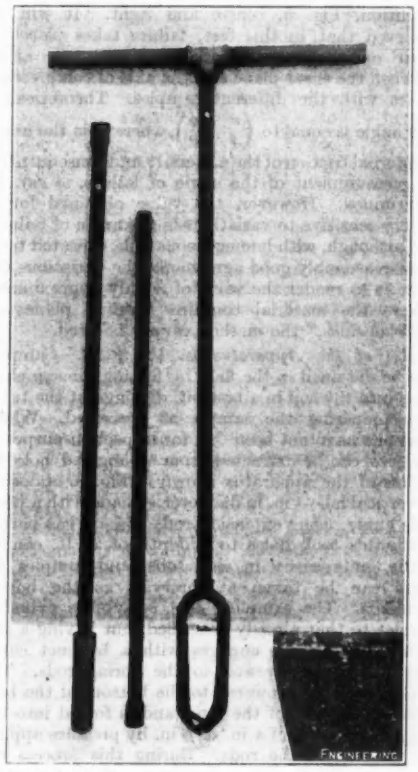


FIG. 8.

PORTABLE APPARATUS FOR COMPRESSION TESTS ON CLAY SOILS.*

By L. F. COOLING, M.Sc., and H. Q. GOLDER, M.Eng., A.M.Inst.C.E.

IN an investigation of the stability of earthworks and foundations, one of the major difficulties is that soil strata are rarely, if ever, homogeneous. It is essential, therefore, to obtain a measure of the degree of variation over the particular site of those soil properties on which the stability depends. The analysis of stability problems requires a knowledge of the shear characteristics of all the important soil strata within the sphere of influence of the structural loads. A direct determination of the shear characteristics, however, involves a somewhat elaborate technique of testing in the laboratory, which means that, on grounds of cost, such tests must be limited to those samples which represent the most frequent and important soil types. To select these representative samples it is necessary to examine a sufficiently large number of samples to determine accurately the variation in soil type and soil condition in both a vertical and horizontal direction over the whole site. The examination, while being simple and comparatively inexpensive, should be capable of giving a quantitative indication of the degree of variation encountered.

For this purpose some comparatively simple tests have been developed,* of which the following are probably the most valuable for the determination of the index properties of different soils:—(1) The natural moisture content; (2) the Atterberg limit tests; and (3) the compressive strength in the natural state. The natural moisture content, which is that which the soil possesses in the ground, is determined by weighing a sample, drying it at a temperature of 105 deg. C., and finding the loss in weight, the result being expressed as a percentage of the dry weight. The Atterberg limit tests comprise two tests, the lower liquid (or upper plastic) limit, and the lower plastic limit. They serve to indicate whether a soil is predominantly colloidal or sandy. The methods of carrying out these tests are described in the A.S.T.M. Tentative Standard Tests D423-35T and D424-35T, and their significance has been outlined in a paper by Terzaghi.† Consideration of the natural moisture content, in conjunction with the results of the Atterberg tests, provides an index of the condition in which a soil exists in the ground; but a more definite index of the existing shear strength of the material can be obtained, particularly with clay soils, by carrying out compression tests on undisturbed samples. In addition, it has been shown‡ that, with certain types of clay soils, the compressive strength is approximately twice the shear strength; and in such cases the compressive-strength figures can be used for at least an approximate analysis of stability. The determination of the compressive strength of samples, therefore, is an important measurement. In the course of the work on soil mechanics at the Building Research Station of the Department of Scientific and Industrial Research, a convenient portable form of apparatus (which can be used both in the field and in the laboratory) has been developed for carrying out compression tests on samples of clay soils. The object of the present article is to give a brief account of the apparatus, and to describe the way in which it can be used in the field. In addition, a simple method of procuring test samples from depths down to about 25 ft. in clay soils is described.

Description of Apparatus.—The apparatus, shown in Figs. 1 and 2, opposite, consists of a spring-

* Text and illustrations, Crown copyright reserved.

* "Sub-Grade Soil Constants, Their Significance and Their Application in Practice," by Hogentogler, Wintermeyer and Willis. *Public Roads*, vol. 12, pages 89-108, 117-144 (1931-2).

† "Simplified Soil Tests for Sub-Grades and their Physical Significance," by Professor Charles Terzaghi. *Public Roads*, vol. 7, page 153 (1926-7).

‡ "Shearing Resistance of Clay Soils," by L. F. Cooling and D. B. Smith, *Journal of the Institution of Civil Engineers*, vol. 3, number 7, page 333 (1936).

loaded device in which a cylindrical specimen of clay soil is subjected to an axial compressive stress, the load-deformation curve being drawn by an autographic recording mechanism. The sample is a cylinder of clay, 1½ in. in diameter, and 3½ in. to 3¾ in. long. The ends are hollowed out by means of a special cutter, shown in Fig. 3, on page 56, so that they fit cone-shaped end pieces (shown in Fig. 2). These cones reduce barrelling and tend to preserve the cylindrical shape of the specimen during compression. They also assist in centring the specimen in the machine. Experience has led to the use of cones with base angles of 10 deg. and 15 deg., the larger angle being used when testing softer material. The cones are smeared with a thin film of oil before the specimen is placed in position. The specimen is compressed longitudinally between the conical bearing surfaces of plates *a* and *b*, Fig. 2. The upper bearing plate is fixed, and the lower plate slides on the vertical rods *c*, friction between the sliding surfaces being reduced by the use of adjustable bearing screws carrying hard steel balls in their ends. Plate *b* is moved upwards by the pull of the compression spring *d* on the cradle *e*, the connecting rods passing through clearance holes in the plate *a*. The upper end of the spring is attached to the plate *f* which is fitted with brass sleeves sliding on the rods *c* to locate the plate in a horizontal plane. The combined nut and handle *g* moves the plate *f* by means of a long rod, screwed 26 threads per inch, a thrust race being inserted between the top plate and the handle.

The apparatus is fitted with an autographic recording mechanism, the record chart being carried on a vertical plate fixed to the sliding plate *f*. A spring-loaded pencil or recording pen is carried on the long arm of a bell-crank lever pivoted on the moving bearing plate, as can be seen in Fig. 1. The short arm of the lever bears on a stop *h*, Fig. 2, the height of which can be adjusted by a screw to bring the pencil to the origin of the record chart at the beginning of the test. The vertical movement of the chart is equal to the extension of the spring plus the deformation of the specimen, while that of the pencil is equal to the deformation of the specimen; hence the differential vertical movement between pencil and paper is proportional to the load on the specimen. Also, since the vertical movement of the pivot of the bell crank is equal to the compression of the specimen, and since the short end of the crank bears on a fixed level, the movement of the pencil along an arc with its centre at the pivot is a function of the deformation. This allows the apparatus to be calibrated to give a direct reading of deformation. The arms of the bell-crank lever give a magnification of four times the deformation, and special charts are used from which both the load in pounds and the deformation in inches can be read directly. For testing materials of widely varying strengths it is convenient to have a series of springs of different stiffnesses. If the ratios of the stiffnesses are whole numbers, the same charts can be conveniently used for all the springs, the actual load being the load shown on the chart multiplied by the ratio of the stiffnesses of the spring used to that of the spring for which the chart was prepared. During the test the cross-section of the specimen increases, and this increase should be allowed for in the calculation of the maximum stress. The assumption is made that the volume of the specimen remains constant and that the shape remains a cylinder. The maximum stress can then be obtained by calculating the stress at a few points near the maximum load, and allowing for the increase in area. For a given size of specimen, a series of constant-stress lines can be constructed and drawn on transparent material, Fig. 4, page 56. The maximum stress can be read off directly from these curves if the pencil is at the origin at the beginning of the test.

Testing Procedure and Typical Results.—The samples are obtained by use of a brass sampling tube 6 in. long and 1¼ in. internal diameter, one end of which is bevelled on the outside to form a cutting edge, as shown on the right in Fig. 3. The tube, greased inside and out, is forced into the soil for a depth of about 4 in. and then twisted through 360 deg. to shear off the soil at the bottom of the tube; the surrounding soil is then removed to release the tube containing the sample. The clay is trimmed off flush with the end of the tube, and a conical recess is formed in the trimmed face of the clay by means of the rotary cutter already referred to. A brass cone, 1$\frac{7}{16}$ in. in diameter, is then oiled and placed on the recessed end of the sample, and the cone and sample are pushed to the other end of the sampling tube by means of the steel rod, also shown in Fig. 3. When the sample projects from the end of the tube it is cut off to give the correct length of specimen (indicated by a mark on the steel rod), and this end is also shaped with the cutter. The specimen is then pushed out of the tube, the brass cone removed from the end, and the sample is ready for testing. The sample is carefully centred in the machine, and when it is just held between the top and bottom cones the pencil is set to the origin. The handle is rotated at approximately one half a revolution per second until failure occurs. Figs. 5 and 6, opposite, show typical failures for different soils, and Fig. 7, typical load-deformation records. The samples shown in Figs. 5 and 6 include, on the left in each case, a highly-colloidal clay soil in a soft condition; a clay soil of a more frictional type at a stiff consistency, Fig. 5, centre and right; and a silty clay in a soft condition, Fig. 6, centre and right. It will be observed that, in this test, failure takes place by shear on a diagonal plane, and that the angle between the shear plane and the axis of compression varies with the different samples. Theoretically, this angle is equal to $\left(\frac{\pi}{4} - \frac{\phi}{2}\right)$, where ϕ is the angle of internal friction of the material; and consequently, by measurement of the angle of failure, ϕ can be determined. However, the value obtained for ϕ is very sensitive to variations in the angle of failure, and although, with homogeneous soils, repeated tests show reasonably good agreement, the variations are such as to render the value of ϕ only approximate. Where the material contains bedding planes or "slickensides," the method cannot be used.

Use of the Apparatus in the Field.—Samples can be obtained in the field by forcing the sampling tube into the soil in a test pit, digging out the tube, and preparing the sample as described. Where trial pits have not been dug for inspection purposes, samples can be extracted from an augered hole by means of the apparatus shown in Fig. 8, opposite. A vertical hole 4 in. in diameter is made with a post-hole auger, using extension rods of ¾-in. gas barrel. With this tool, holes to a depth of 25 ft. can be made quite easily in clay soils, and samples for tests can be taken at intervals as the boring proceeds. The sampling tool is a brass cylinder, similar to that already described, but having a slot at one end which engages with a bayonet catch on an adaptor screwed to the boring rods. The sampling tube is lowered to the bottom of the bore hole on the end of the rods, and is forced into the clay for a depth of 4 in. or 5 in. by pressure applied to the top of the rods. During this process the air or water in the tube is expelled through a hole in the side of the tube, and the hole is sealed by the clay when the sampler is nearly full. The rods are then turned in a clockwise direction through 360 deg. to shear off the clay level with the bottom of the tube, and are then pulled up, bringing the sample in the tube. The tube is detached and the sample prepared as already described. After test, the sample is placed in a press-cap bottle and taken to the laboratory, where it is weighed and its moisture content determined. If, before test, the length of the specimen is measured, its volume can be calculated; and since its weight is known, the weight of the material per cubic foot can be determined. The dried material is broken up and ground to powder, and the liquid and plastic limits determined in the standard manner.

Acknowledgment.—The authors desire to express their thanks to the Director of the Building Research Station, Department of Scientific and Industrial Research, for permission to publish this paper.

TRAVEL IN COLOMBIA.—It is stated in the French journal *L'Air* that the journey from Barranquilla to Bogota, Colombia, which takes 11 days by river steamer, may be accomplished, by air, in three hours.

CORROSION BY THE PRODUCTS OF COMBUSTION OF TOWN GAS.*

By FRANK TAYLOR, B.Sc., and JAMES W. WOOD, M.Sc. Tech.

IN the previous work of the Joint Research Committee upon the corrosion of metals used in the construction of gas appliances, almost the whole of the water produced by the combustion of the gas was condensed on the test-pieces, and a large proportion of the corrosion product was removed in the condensate. On the other hand, in gas appliances it frequently happens that only a portion of the water is condensed, and the condensate runs into hotter regions, where it is continuously re-evaporated and concentrated. Under these conditions severe local attack is possible, with the building up of corrosion deposits to an extent that may cause blocking of flue-ways and have an adverse effect upon combustion. This latter aspect of corrosion is the subject of this investigation. The materials examined were solder-coated and tinned copper, aluminium of various degrees of purity, copper, 70-30 brass, mild steel, chemical lead and chemical tellurium-lead, Monel metal and nickel. Each material was in the form of a 1-in. tube, fitted at the top with a water jacket and insulated along the rest of its length. The water vapour produced from the gas burned at the bottom of each tube was partially condensed on the water-cooled section of the tube. This condensate, which, with dissolved sulphur and nitrogen acids, formed the corroding medium, ran down the tube to hotter regions where re-evaporation and concentration occurred. It was possible to follow the growth of corrosion deposits in the tubes by looking down the tubes through the orifice in the cap and also by looking up the tubes with the aid of a mirror. It was intended at first to remove the deposits periodically, so as to obtain information about the rate of corrosion. Had this been done, however, the results might have been misleading, since the protection afforded against further attack by the deposits would vary with different metals. The deposits were thus allowed to accumulate for 32 days; the tubes were then split lengthways to enable the deposits to be examined, after which the deposits were collected by scraping the metal.

The Table, on the opposite page, gives a general review of the results, the metals in each section in this table being arranged in order of "merit." For runs I and II the metals are placed in three groups of good, medium and poor resistance to corrosion under the conditions of the test. In interpreting this table, it must be borne in mind that the degree of obstruction presented by a given weight of deposit is determined by its volume, and position in the flue-way, not by the total weight of deposit. The figures in column 4 of the Table, therefore, do not give a complete picture of the corrosion effects of each metal; there might be greater difficulty with aluminium, giving 5·8 grams deposit, than with iron giving, under the same conditions, 48·5 grams.

The solder-coated copper and the tinned copper have withstood the conditions best, although it must be noted that large amounts of the coating material were found in the deposits and also that, where re-evaporation was occurring, the coating had been completely removed. This shows that, although these coatings reduce corrosion, they do not afford a permanent protection; had the duration of the test been increased, it is evident that, ultimately, the coating would have been removed completely. The tellurium-lead and the chemical lead proved very resistant to attack, the formation of a protective coating of lead sulphate being an important factor. While lead is resistant to corrosion by the products of combustion of ordinary town gas, it would be rapidly corroded if the sulphur compounds were removed completely. Aluminium was used in three different purities, namely, 99·95 per cent., 99·5 per cent., and 98·5 per cent. With each specimen, heavy corrosion deposits were formed locally in the tubes, tending to interfere with the efficient combustion of the gas, but the purest specimen gave only half the corrosion of the other two. The purity of a metal is thus shown to have, possibly, a very important influence upon the course of corrosion. Copper and brass behaved similarly to aluminium in giving a voluminous deposit. With the sulphur content of the gas reduced from 22 grams to 5 grams per 100 cub. ft., however, the time taken for a deposit to increase sufficiently to block up the tubes was increased three-fold. This suggests that, although reducing the sulphur content to 5 grams would not obviate corrosion troubles in a gas water-heater, the life of the appliance would be increased and maintenance costs reduced. With mild steel, although sulphates formed only a small proportion of the total corrosion product, the effect of reducing the sulphur content of the gas was to reduce the corrosion

* "Corrosion by the Products of Combustion of Town Gas under Conditions of Condensation and Re-evaporation." Paper communicated to the Institution of Gas Engineers, 1939.

CORROSION BY THE PRODUCTS OF COMBUSTION OF TOWN GAS.

GENERAL TABLE OF RESULTS OF CORROSION TESTS.

Material.	CO_2 in Dry Flue Gases. Per cent.	Dilution Factor.*	Sulphur in Flue Gases. Gr. per 100 cub. ft.	Weight of Deposit. Gr.	Sulphur in Deposit.		Metal in Deposit. Gr. per 100 cub. ft. of Gas				Metal in Total Deposit Formed during Test. Gr.
					Sulphur. Per cent.	Sulphur Retention. Per cent.	A.	B.	C.	Total Metal (A+B+C).	
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
RUNS I AND II.—AVERAGE SULPHUR CONTENT OF GAS, 22·6 GR. AND 21·0 GR. PER 100 CUB. FT., RESPECTIVELY.											
Solder-coated copper	8·2	5·1	4·43	1·803	11·2	2·6	Sn 0·013	Pb 0·025	Cu 0·094	0·13	0·56
Tinned copper	8·3	5·0	4·52	2·745	10·5	4·6	Sn 0·068	—	Cu 0·173	0·24	1·03
Tellurium lead	8·2	5·1	4·12	4·386	8·1	6·3	Pb 0·64	—	—	0·64	2·64
Chemical lead	8·3	5·0	4·20	4·191	9·6	7·2	Pb 0·66	—	—	0·66	2·82
Specially pure aluminium	7·9	5·3	4·00	5·855	15·3	15·8	Al 0·20	—	—	0·20	0·81
99·5 per cent. aluminium	8·0	5·2	4·04	12·58	15·2	33·8	Al 0·47	—	—	0·47	1·95
Commercial aluminium	8·2	5·1	4·43	12·56	14·5	29·2	Al 0·49	—	—	0·49	2·10
Monel metal	7·8	5·2	3·78	13·67	18·7	45·3	Ni 1·04	Fe 0·05	Cu 0·08	1·17	4·86
Soft copper	8·2	5·1	4·43	20·22	15·8	51·0	Cu 1·63	—	—	1·63	6·98
Brass (70/30)	8·1	5·2	4·35	23·88	16·0	60·8	Cu 1·16	Zn 0·81	—	1·97	8·41
Nickel	7·8	5·3	3·78	27·35	17·2	83·3	Ni 1·99	—	—	1·99	8·25
Mild steel	8·1	5·2	4·35	48·54	7·0	54·4	Fe 4·54	—	—	4·54	19·42
RUN III.—AVERAGE SULPHUR CONTENT OF GAS, 5·22 GR. PER 100 CUB. FT.											
Tinned copper	7·4	5·3	0·98	1·803	8·7	10·5	Sn 0·065	—	Cu 0·048	0·113	0·49
Chemical lead	7·2	5·5	1·00	4·630	5·4	16·7	Pb 0·69	—	—	0·69	3·04
Specially pure aluminium	7·3	5·4	0·97	3·568	12·6	30·2	Al 0·132	—	—	0·132	0·58
Soft copper	7·3	5·4	0·97	6·919	15·7	72·8	Cu 0·54	—	—	0·54	2·39
Brass (70/30)	7·4	5·3	0·98	7·407	15·9	79·0	Cu 0·22	Zn 0·39	—	0·61	2·70
Mild steel	7·4	5·3	0·98	27·25	4·2	76·2	Fe 2·68	—	—	2·68	11·83

* Cub. ft. of dry flue gases per cub. ft. of gas burned.

by nearly half. The results of the experiments indicate clearly that reduction of the sulphur content of town gas from its common value of 20 grams to 30 grams to a figure of 5 grams per 100 cub. ft. would benefit to a large extent the utilisation side of the gas industry by reducing maintenance and replacement charges.

With Monel metal, it was found that the nickel had been removed preferentially from the metal, very little of the copper having been removed. It appears that the alloy is not first attacked as a whole followed by a re-deposition, as occurs with brass. The most serious aspect of the corrosion lies in the local formation of heavy deposits, which would tend to block up the flue-way of an appliance made from this material, causing interference with the combustion of the gas. Nickel must be classed among the metals offering poor resistance to corrosion under these conditions of attack.

ELECTRIC TROPENAS PROCESS OF STEEL MANUFACTURE.

AN interesting new modification of a well-known steelmaking process, for which a number of advantages are claimed, has recently been brought to our notice by Messrs. Campbell and Chiverton, 7, Lovell's-court, Paternoster-row, London, E.C.4. This is termed the Campbell system electric-Tropenas process, and utilises a Tropenas furnace incorporating specially-designed electrical equipment for raising the temperature of the metal bath after additions of alloys. The Tropenas side-blown converter, it will be recalled, employs two rows of tuyeres on one side. The lower set directs the blast on to the surface of the melt, while the upper set supplies air for the combustion of the carbon monoxide to carbon dioxide. The addition of nickel, ferro-chromium and other alloys in large quantity to blown Tropenas charges sometimes offers difficulties, and it is to superheat the bath after the removal of the slag, and thus to ensure the complete fusion of the alloy additions, that electric heating has been superimposed on the ordinary Tropenas process. The furnace employed is rectangular instead of circular in cross-section, and a portion of the wall of the furnace, on the tuyere side, is capable of being removed and replaced by a replica section embodying electrodes.

Another feature of the equipment is that attached to the tuyere box is a sealed hopper containing partitions, in the compartments of which are placed granulated ferro-silicon, manganese, chromium or nickel. These materials may be impelled forward into the molten bath during blowing operations by means of tubes leading into the tuyere orifices. Attached to the main air pipe, and connected with the hopper, is an air-balancing conduit. This arrangement for adding say, high-grade ferro-silicon in order to raise the temperature of the melt is stated to be very effective and more economical than throwing lump ferro-silicon into the mouth of the converter during the blowing period. The attachments, when not required, in no way obstruct the normal working of the process.

The operation of turning down the converter after the blowing operations, removing the section of wall and lowering the replica embodying electrodes into position and adjusting the arcs, it is stated, occupies a few minutes only. On completion of the electrical heating, during which a light removable refractory cover seals the converter mouth, the portion containing the electrodes is removed, the solid section replaced, and the charge poured.

The average time taken to produce 1 ton of a stainless-steel alloy is given in the following time sheet, which, it is pointed out, is an actual works record :—

9.30 a.m. Pig iron and scrap charged into converter (1 ton).

Analysis.

Total carbon	3·00	per cent.
Silicon	2·20	,,
Sulphur	0·03	,, (by soda-ash treatment).
Phosphorus	0·03	,,
Manganese	0·80	,,

10.0 a.m. Charge blown.

Analysis.

Carbon	0·09	per cent.
Silicon	0·01	,,
Sulphur	0·033	,,
Phosphorus	0·035	,,
Manganese	Trace.	

Additions (cold): ferro-manganese, ferro-silicon, nickel, ferro-chromium, etc.

10.5 a.m. Arcs operating.

10.20 a.m. Metal bath ready for teeming.

In addition to alloy steels, the process is claimed to be particularly suitable for the production of ordinary carbon steels and special high-duty alloy cast irons, while the plant may be employed also for melting metals and alloys from the cold. When used for this purpose, the charge is melted by the arcs, after which the metal in the converter is finished by blowing in the normal way.

LIFE-BOAT CONSTRUCTION IN 1939.—We are informed that 17 new motor life-boats were completed and sent to stations of the Royal National Life-Boat Institution during 1939 and that 10 more are under construction. There are now 145 motor life-boats and 15 pulling and sailing life-boats round the coasts of Great Britain and Ireland.

SELF-CONTAINED REFRIGERATING PLANT.

THE increasing use of air conditioning in theatres, large shops and hotels has imposed a number of new conditions on the design of the refrigerators, which are an essential of such equipment. In the first place, all factors which might conceivably be harmful to health must be eliminated while noise and vibration must be reduced as much as possible. A high degree of reliability in service is also desirable. This means that the machines must be gastight and that those refrigerants which are least liable to explode or ignite must be given preference. Finally, the space occupied by the plant plays an important part.

All these matters, it is claimed, have been taken into consideration in the design of the Frigibloc refrigerating unit which is constructed by Messrs. Brown, Boveri and Company, Limited, Baden, Switzerland. This consists of a self-contained refrigerating plant, which is designed for outputs of from 100,000 kilocalories to 2,000,000 kilocalories per hour. The evaporator, compressor and condenser, as well as the driving unit, are contained in a gastight cylindrical housing. The compressor is of the multi-stage centrifugal type, as this is less subject to vibration and occupies only about one-third of the space required by one of the reciprocating type. The housing, therefore, is both cheap and light. Wear is also reduced, and as there is no contact between the lubricating oil and refrigerant, the vapour passing through the compressor is clean. The result is that the consumption of lubricating oil is reduced to a minimum, and there is no soiling of the evaporator or condenser tubes, so that the coefficient of heat transmission is reduced to a minimum. That this is of importance will be clear when it is stated that an oil layer only $\frac{1}{10}$ mm. thick will cause the heat-transmission coefficient to drop by as much as 40 per cent.

A valuable feature of the design is that the pressure-volume characteristic of the turbo-compressor permits the refrigerating output to be automatically adjusted to the consumption over a wide range. Thus, as the refrigerating output falls, the compressor generates a rising pressure ratio and a correspondingly lower true temperature. On the other hand, with a reduced temperature drop, such as occurs when starting up after a long period of rest, the delivery volume handled by the compressor increases as does the refrigerating output, so that the attainment of normal running conditions is accelerated. The maximum pressure rise is about 20 per cent. above the normal value, so that even if the gas circulation is stopped (as happens when the pressure valve is completely closed) no dangerous pressure can occur. No safety valve, therefore, is needed.

A number of halogenated hydrocarbon derivatives are very suitable as refrigerants for turbo-compressors,

because their vapours have sufficiently large specific volumes and moderate pressure conditions in the temperature range required in practice. In the Brown-Boveri Frigibloc units, methylene chloride (CH_2Cl_2) is used. This should not be confused with the less innocuous methyl chloride (CH_3Cl). Certain Freon compounds are also employed. All these refrigerants, besides being relatively innocuous, are also characterised by low pressures; in fact, at 25 deg. C., methylene chloride has a pressure of only about 0·58 kg. per square centimetre absolute. This means that the cycle in Frigibloc takes place entirely under vacuum, given the usual evaporation and cooling water temperatures. Thus any leakage that might possibly occur in the system will not be accompanied by an escape of gas, and though some air might penetrate, it is claimed that this is usually prevented by the flange seals employed. Any air which enters the refrigerator when the cover is raised for overhauls is evacuated by a vacuum pump, which runs as required. This pump also serves to exhaust air which may have penetrated into the system through leakage. The presence of air is indicated by a special instrument.

With the refrigerants used in the unit, there is little heating up under compression. The compressor can, therefore, be built without a cooling circuit with considerable simplification, both in design and running. By placing the warm condenser at the top and the cold evaporator at the bottom, there is a natural flow of heat through the unit. The influx of heat from outside, therefore, is very small, even without insulation. From the chemical standpoint, the refrigerants employed are neutral as regards the materials employed in construction. The motor, if it is of the three-phase type, can, therefore, be located inside the housing, thus eliminating sealing glands; in fact, the only bushing is the one for the cable heads and the only connecting pipes are those for the water and the brine. It is claimed that the unit is specially suitable for automatic service either with or without a storage tank as it is designed that should the cooling water fail the compressor will stop. Stoppage will also occur if the temperature of the condenser becomes too high or that of the brine too low. Further, any leakages of water or brine are automatically indicated.

THE INSTITUTION OF STRUCTURAL ENGINEERS.—The annual dinner of the Institution of Structural Engineers will be held at the Dorchester Hotel, Park-lane, London, W.1, on Friday, March 1.

COAL-GAS CARBURETTORS FOR RUNNING-IN AND ROAD SERVICE.

MESSRS. THE GAS LIGHT AND COKE COMPANY, LONDON.

Fig. 1.

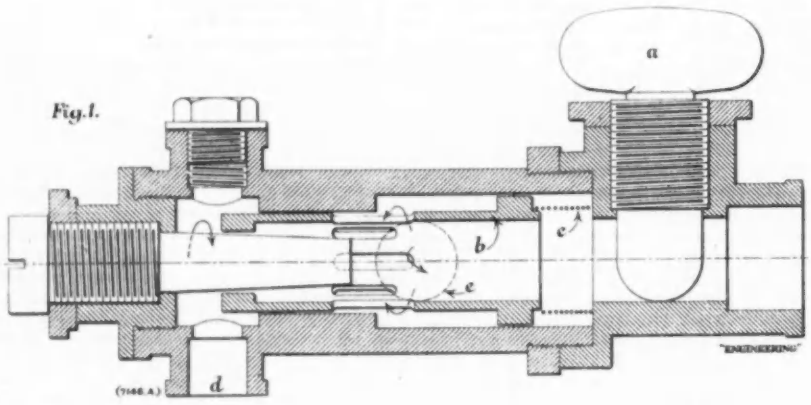


Fig. 2.

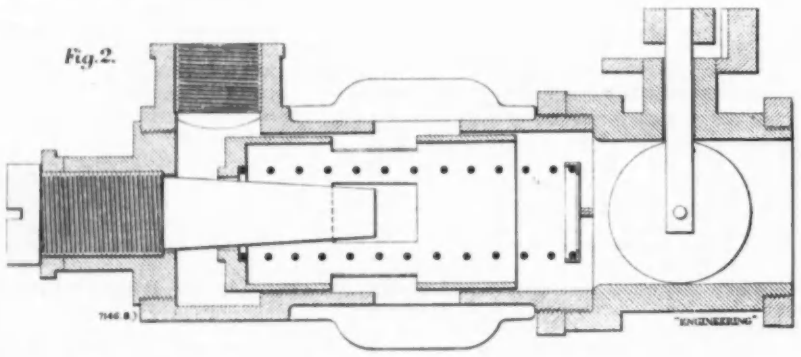
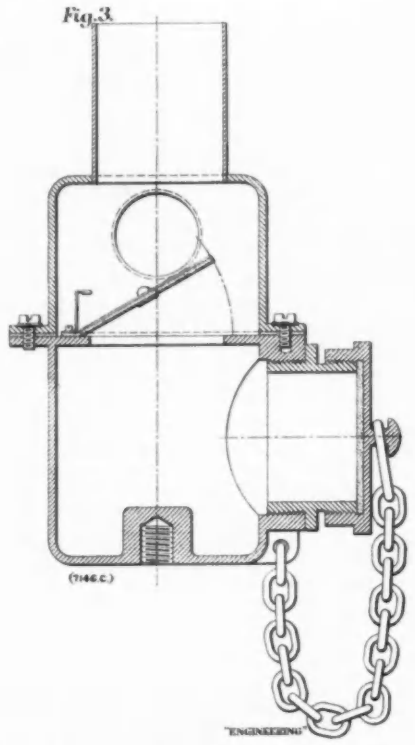


Fig. 3.



As mentioned on several recent occasions, wide interest is being taken at present in the employment of fuels other than petrol for road transport. Of these, ordinary coal gas is among the more important. It has long been used for running-in engines after assembly, and a carburettor designed primarily for this purpose is illustrated in Fig. 1, on this page. The first essential feature of this procedure is that the engine should be run at a low speed with no load in order to bed down the moving parts. Gas forms a very suitable fuel for this purpose, as accurate control of the fuel-air ratio is possible at low speeds and combustion is complete; whereas on petrol under the same conditions vaporisation is apt to be defective and the operating efficiency low. A further common disadvantage of running-in on petrol is the presence in the exhaust gases of unburnt or partially-burnt fuel, which necessitates the provision of adequate ventilation; while needless wear of the cylinder walls may occur due to unvaporised petrol removing the protective oil film. Apart from these considerations, gas lends itself very conveniently to making the connections from the source of supply to the carburettor, and also represents a very appreciable economy in the cost of running-in. With gas having a calorific value of 500 B.Th.U. per cubic foot, 250 cub. ft. (1·25 therms) are equivalent to 1 gallon of petrol. At the domestic gas rate this figure corresponds to petrol at 1*s.* 3*d.* per gallon. Finally, gas is a non-knocking fuel, so that high-compression engines can be run-in without the necessity of providing expensive high-grade fuel. After running-in light, it is customary to apply load gradually until the engine is developing about two-thirds of its maximum power, to complete the bedding-in process. Although, as is well known, the power developed on gas is lower than that developed on petrol, it is amply sufficient for all running-in requirements.

The carburettor illustrated in Fig. 1 is designed by The Gas Light and Coke Company, Horseferry-road, London, S.W.1, and is known as the G.L.C. Gas Mixer. The carburettor is of the single-control type, designed to give maximum power and economy at all engine speeds, and to cut off the gas supply completely when the engine is stationary. It can be adjusted to give mixtures of different air-gas ratios, and to allow for variations in gas quality. The mixture outlet is shown on the right in the figure, and immediately in front of this is the throttle valve *a*. The valve shown consists of a thumb-screw with a fine thread, the lower end of the screw being of cylindrical form and terminating in a hemisphere. The passage is so designed that it is completely closed when the thumb-screw is screwed fully home, and affords uninterrupted flow when in its upper position. This type of throttle is designed to give an accurate fine control. For rapid operation, it can be replaced by a butterfly valve, the portion of the carburettor body carrying the thumb-screw being made detachable, as shown, for this purpose. The main body of the carburettor contains a piston *b*, which is free to slide, and is normally held by the spring *c* in the position where its left-hand end is in contact with the face of the end plug. In this position, the gas passage *d* is closed, and also the air passage *e*. The only connection between this passage and the carburettor outlet is through the slots shown in the piston, and in the position of the piston referred to, these slots are closed by the carburettor body. Assuming the throttle is open, as soon as the engine is pulled round for starting up, a partial vacuum will be created on the engine side of the piston, and the latter will move to the right through a distance depending on the degree of depression, or engine suction. This will have the effect of opening both the gas and air ports, so that mixture will be delivered to the engine, which will accordingly fire. Once the engine is running, the position of the piston will be determined by the throttle opening, since the latter will determine the depression in the carburettor itself. It will be observed that the gas enters the interior of the piston through a port in the left-hand end, the area of which is controlled by its traverse along a tapered plug, and the degree of taper is such that a correct mixture is maintained with the increasing volume of air supplied as the air slots open. Owing to dynamic effects in the mixture, it is necessary to increase the air supply more rapidly than the gas supply at high speeds, and additional air slots are provided in the piston for this purpose, as shown. Adjustment of the carburettor for variations in gas quality are effected by altering the position of the tapered plug in the carburettor body, for which purpose the left-hand end is threaded and provided with a lock nut, as shown. A carburettor for use on vehicles operating on coal gas, whether carried in flexible gas bags or high-pressure cylinders, is illustrated in Fig. 2. This carburettor is also designed by The Gas Light and Coke Company, and it will be observed that it is practically identical with the one already described, with the exception that the thumb-screw throttle is replaced by one of the butterfly type.

In addition to these carburettors, a filling valve for flexible gas containers fitted to vehicles has been approved by the Industrial Gas Centres Committee at Gas Industries House, and is illustrated in Fig. 3.

4½-IN. VERTICAL BORING AND TAPPING MACHINE.

CONSTRUCTED BY MESSRS. THE NATIONAL ACME COMPANY, CLEVELAND, OHIO, U.S.A.

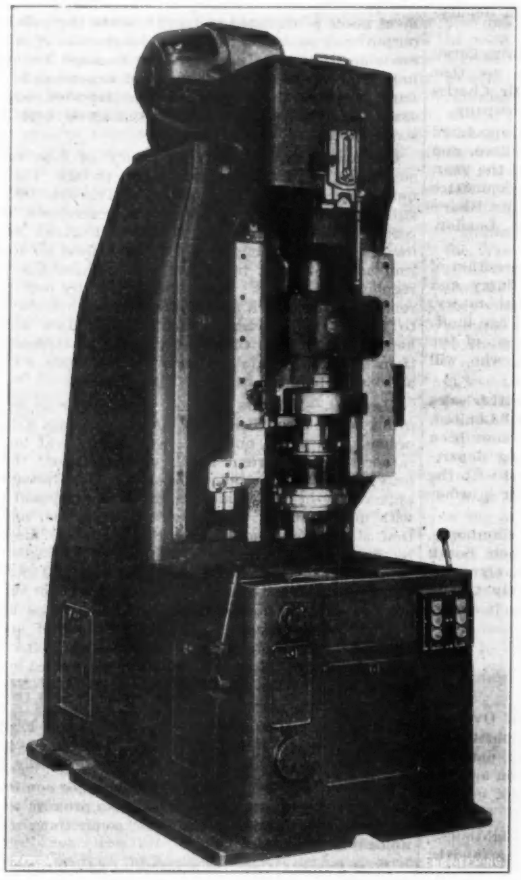


FIG. 1. OPERATING SIDE OF MACHINE.

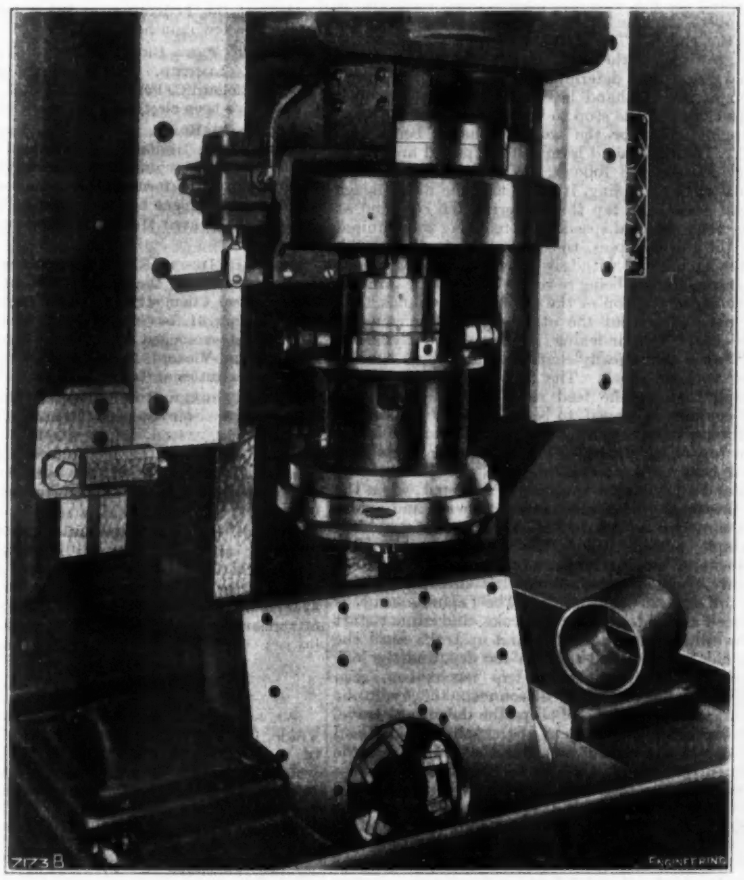


FIG. 2. CHUCK IN MID-WAY POSITION.

The filling valve is mounted on the vehicle itself, and the connection to the container is made at the top, while the branch shown in the centre forms the engine connection. The connection for the gas supply when charging the bag is shown on the right fitted with a sealing cap. To prevent gas leakage during the process of disconnecting the charging hose and securing the cap, the fitting incorporates a non-return valve of the flap type. The body of the filling valve is a well-finished brass casting. The flap valve is made of aluminium faced with leather lightly treated with a heavy mineral oil after being secured to the disc. The resistance to gas flow does not exceed 0·25 in. water gauge at 2,000 cub. ft. per hour.

This filling valve has been designed as a standardised fitting to overcome the difficulties experienced by operators owing to the different sizes of standpipe in use in garages and local gas undertakings. The inlet is provided with a 2-in. British standard pipe thread, and the outlets to the bag and carburettor with 2-in. and 1¼-in. connections, respectively. In the case of large lorries or 'buses, an increase in the size of the carburettor connection to 1½ in. or 2 in. may be necessary, but this alteration can be readily carried out by the firm fitting the valve to the vehicle or by the valve manufacturers. These valves can be obtained from Messrs. Wm. Sugg and Company, Limited, Ranelagh Works, Chapter-street, S.W.1, or from Messrs. Evered and Company, Limited, Surrey Works, Smethwick, Birmingham. If preferred, full drawings can be obtained from The Industrial Gas Information Bureau, Gas Industry House, Grosvenor-place, S.W.1, price 1*s.* 6*d.*

SWANSEA TIN-PLATE AND GALVANISED-SHEET INDUSTRY.—The Incorporated Swansea Exchange, Royal Metal Exchange, Swansea, informs us that the inquiry for tin-plate, on both home and export account, is maintained, and that the makers have upwards of 10½ million boxes on their books. There is a strong demand for galvanised-steel sheets for A.R.P. purposes, while business with ordinary users is increasing. There is no slackening in the exceptionally heavy demand for iron and steel scrap.

VERTICAL BORING AND TAPPING MACHINE.

THE special-purpose machine tool affords a field for the ingenuity of the designer which, perhaps, does not exist to the same extent with the more conventional types. The vertical boring and threading machine which is shown in the illustrations, Figs. 1 and 2, on this page, is a good example of the manner in which the unusual problems of the special-purpose machine are solved. The machine illustrated is manufactured by Messrs. The National Acme Company, 170, East 131st-street, Cleveland, Ohio, U.S.A., and has been designed particularly for the precision threading or finish-boring of couplings for the high-pressure pipes used in the oil industry. These couplings, as will be clear from the example at the right of Fig. 2, are plain sleeves with internal threads. The term "threads" is used advisedly, since the coupling is screwed with a taper thread from both ends. Two operations are needed, therefore, on each coupling, and, as will be realised, it is very important that both threads should be accurately aligned. The usual method of tapping a hole with rigidly-held tools and floating chucks has been discarded in favour of keeping the work rigid and floating the tap vertically into it. The coupling, after one end has been tapped, is then turned upside down, *i.e.*, through an arc of 180 deg., and the other end is tapped. Since the jaws of the chuck are not released from the work between the opposed tapping operations and the chuck is rotated in bearings not permitting either axial or lateral movement, it follows that one end of the finished coupling is always in alignment with the other as regards the taper bores and in accuracy of thread.

The machine is semi-automatic in operation and is operated partly mechanically and partly hydraulically. The chuck is mounted on heavy trunnions at the front of the deep baseplate and, though it can be made out in Fig. 1, it is more clearly seen in Fig. 2, being there shown in the act of turning from one position to the other. The rear of the baseplate carries a substantial column housing the hydraulic pump, tank and the counterweight for the spindle head. The driving motor is mounted on top of the column, and to the front of the column is bolted a casting comprising the gearbox at the upper part, with the guide ways for the spindle head below, these ways being hardened and ground. Adjustable liners for taking up wear are provided. The spindle is mounted in the head in adjustable precision-type anti-friction bearings and is driven from the gearbox through a splined shaft and worm gear, and double-helical gears of heat-treated alloy steel. The traverse of the head is affected by a lead screw, as regards feed, different rates being provided by change gears, only one change gear needing to be altered for each pitch required. The engagement of the split nut with the lead screw for effecting feed traverse is hydraulically-actuated, as is also the rapid traverse up to the work. The split-nut lead-screw mechanism is designed to engage always with the same load, the counterweight being so proportioned as to exert a constant slight pressure against the lead screw.

The floating device on the spindle, for the purpose of carrying the taps, is fully enclosed and operates in lubricating oil between friction-reducing hardened and ground plates. The tap employed is the Namco positive-acting collapsing type, which has a receding core piece to withdraw the chasers inward under the control of an internal taper lever, thus insuring accuracy of taper of the thread formed. The chuck is hydraulically-operated both as regards its indexing and locking, and the opening and closing of the jaws. There are three jaws, but, as shown in Fig. 2, each has two contact edges, the work being thus gripped at six points circumferentially. The jaw pressure can be varied to suit the wall thickness of different couplings and is indicated on two pressure gauges, so that undue pressure, tending to deformation, can be guarded against. The hydraulic system consists of a vane-type constant-speed pump, driven by electric motor, with a hydraulic motor for the chuck indexing movement. Driving motor and pump motor are push-button controlled from the front of the baseplate, the three push-buttons seen to the right of the column actuating an auxiliary switch which provides three speeds on the variable-speed driving motor, apart from the change gears. All the driving gears run in an oil bath and a spray of lubricating oil is provided elsewhere, the

bearings being automatically flushed each time the chuck is opened. The supply of cutting lubricant is controlled by a valve actuated by movements of the spindle head, so that a flow only takes place during cutting and not when loading is being done.

A working cycle may now be considered. The left-hand lever, see Fig. 1, is first pushed over, a movement which opens the chuck jaws and causes a stop to swing under the chuck. The coupling is then placed in the chuck, resting on the stop, the precise depth to be screwed being thus determined; release of the spring tension of the left-hand lever then causes the chuck jaws to close and the stop to withdraw out of the way, a swinging door for the work discharge being also closed. The right-hand lever is then pulled and rapid traverse of the tap follows. When the tap reaches the face of the coupling, it stops and the nuts engage the lead screw, the tap then entering the coupling at the correct rotational speed. On reaching the required depth the tap collapses, the lead screw is disengaged, and the spindle is withdrawn by the rapid-traverse mechanism, the tap being re-set to the working position on arriving at the top of the stroke. The chuck then turns over to present the other end of the coupling to the tap. This indexing is done by a hydraulic motor, an automatically-controlled lock bolt causing seating without shock. The tap descends rapidly at first and then at the feed rate, and the other end of the coupling is tapped, to be followed by withdrawal as before, although this time the spindle head remains at the top of its stroke. The left-hand lever is then pushed back, this motion releasing the jaws of the chuck and allowing the coupling to drop out, when the door, previously mentioned, swings forward and guides it to a conveyor for delivery at the rear of the machine. An ample passage below the chuck provides free movement of cutting lubricant and swarf.

Clearly, such a sequence as that described above calls for certain safeguards. The spindle head is cushioned at the top of the upstroke, and cannot start its downward travel after the first upstroke until the chuck has been indexed through 180 deg. and the lock bolt seated. The adjustable trip mechanism, seen at the left hand in Fig. 2, disconnects the hydraulic rapid-traverse cylinder and stops the downward travel of the tap before engagement of the split nut and lead screw causes the chasers to enter the coupling at the proper cutting speed. Should the tap fail to collapse for any reason, a snap-lock limit switch, seen on the front of the gearbox in Fig. 1, will stop the machine instantly. The right-hand lever cannot be pulled to start the spindle head until the left-hand chucking lever has been released, nor can the latter lever be manipulated at all until both ends of the coupling have been tapped. Similarly, controls for all related moving parts are so interlocked as to afford full protection to operator, machine, and work alike. A compensator device is provided in connection with the lead screw to enable rapid adjustment, plus or minus, to be made, so that operation under changing temperatures and other conditions do not affect the accuracy of the thread. The machine illustrated is suitable for tapping couplings ranging from 2 in. to 4½ in. in diameter of thread, flat-type ground-thread chasers being employed up to 4 in. in diameter; above this size circular ground-thread chasers are employed. Two larger sizes of machine are manufactured to tap up to maximum diameters of 8⅝ in. and 13¾ in., respectively. So far, only the operations of tapping have been referred to, but it will be clear that, with suitable tool equipment, finish-boring can be done on it. For rough-boring, certain modifications are necessary, for example, the replacement of the lead-screw mechanism by an adjustable hydraulic valve control.

WHITAKER'S ALMANAC, 1940; CORRIGENDUM.—We regret that, in the review of *Whitaker's Almanack*, which appeared on page 36 of our last week's issue, a reference to a previous number of ENGINEERING was omitted. The reference was to an article on Wandsworth Bridge, on page 707 of ENGINEERING for December 29, 1939.

REPAIRS TO OIL-TANK MOTORSHIP "JAGUAR."—Last January, the twin-screw oil-tank motorship Jaguar, built in 1928, was cut in two in very heavy weather in the Atlantic. The forward portion of the ship sank but the after portion remained afloat and was towed to Holland. The vessel originally had a length of 475 ft. 8 in., a beam of 64 ft. and a tonnage of 9,721. The after portion of the ship, which contained the twin-screw, single-acting, four-cycle Burmeister and Wain Diesel engines, was examined and found to be in excellent condition, and it was decided to build a new forward portion, the work being entrusted to Messrs. Netherlands Graving Dock Company, Amsterdam. The new forward portion was constructed on a shipbuilding berth and launched on November 4, 1939, and the two halves of the ship were assembled in a floating dock. The trials of the reconstructed tanker are to take place this month.

PERSONAL.

LORD DUDLEY GORDON, D.S.O., has been nominated President of the Federation of British Industries, 21, Tothill-street, London, S.W.1, for the coming year. He is ex-President of the British Engineers' Association and has served for a number of years on the Grand Council of the Federation and was appointed deputy-president a few months ago.

MESSRS. THE BRUSH ELECTRICAL ENGINEERING COMPANY, LIMITED, Loughborough, inform us that Captain Richard C. Petter, M.I.Mech.E., and Mr. Charles L. Hill have been elected to the board of the company.

MR. W. R. BLAIR, M.C., LL.B., has been appointed Director of the Ironfounders' National Committee, and entered on his new duties at the beginning of the year. An account of the formation and aims of the Committee will be found on page 447 of our last volume. Mr. Blair's office is at Orchard House, 30, Orchard-street, London, W.1.

DR. C. H. DESCH, F.R.S., retired from the position of Superintendent of the Department of Metallurgy and Metallurgical Chemistry, National Physical Laboratory, on December 31, having attained the normal age limit. He will be succeeded by Mr. C. Sykes, D.Sc., of the Metropolitan-Vickers Research Laboratories, who will take up his duties at Teddington on March 1.

MR. R. TURNER HOOD, formerly chief Scottish sales representative for Messrs. British Timken, Limited, Cheston-road, Aston, Birmingham, 7, has now been appointed chief of the mechanical-engineering department of the company. He has been associated with the manufacture and application of ball and roller bearings for the last 13 years.

MESSRS. HOLMAN BROTHERS, LIMITED, Camborne, Cornwall, announce that the address of their South Wales branch office has been changed to 210, Cyncoed-road, Cardiff. The telephone number, namely Cardiff 3258, is unaltered, and Mr. W. D. Rule remains in charge of the branch.

TENDERS.

WE have received from the Department of Overseas Trade, Great George-street, London, S.W.1, particulars of the undermentioned tenders, the closing dates of which are stated. Details may be obtained on application to the Department at the above address, quoting the reference numbers given.

Engine and Water Pump for the Shedwan Lighthouse, Red Sea. Ministry of Communications, Alexandria, Egypt; February 10. (T.Y. 15,037/40.)

Heavy Cast-Iron Pipes, junctions and bends (spigot and socket) and air stop valves (Globe pattern). Main Drainage Department, Ministry of Public Works, Cairo, Egypt; February 6. (T. 15,042/40.)

Structural Steelwork for a 600-ton coaling plant for Pietersburg. South African Railways and Harbours, Johannesburg; February 5. (T. 15,057/40.)

Pressed-Steel Tank, 42,000-gallon capacity, 32 ft. by 28 ft. by 8 ft. deep, open top; together with a 22-ft. high tower. South African Railways and Harbours, Johannesburg; February 23. (T. 15,058/40.)

Cable, VIR-insulated, tough-rubber compound sheathed, having three active conductors suitably insulated for use on a three-phase, 6·6-kV system. State Electricity Commission of Victoria, Melbourne, Australia; April 2. (T. 15,010/40.)

Steam Tug, twin-screw, for use in salvage, towing and fire-fighting, and having a length, between perpendiculars, of about 140 ft. Ports and Lighthouses Administration, Alexandria, Egypt; February 25. (T. 15,038/40.)

Insulators, Stay Wire and Copper Conductor. Salisbury Municipality, City Hall, Salisbury, Southern Rhodesia; February 5. (T. 15,120/40.)

Copper Aerial Cable, triple-braided. State Electricity Commission of Victoria, Melbourne, Australia; February 13. (T. 15,259/40.)

Steel-Wire Conveyor Belts, open-mesh, 500 lineal feet, 34 in. wide, and 110 lineal ft., 28 in. wide, for briquetting works, Yallourn. State Electricity Commission of Victoria, Melbourne, Australia; February 6. (T. 15,260/40.)

Cables and Cable Boxes. Public Works Department, Wellington, N.Z.; February 13. (T. 15,292/40.)

Locomotive Boilers. With reference to the call for tenders by the Eastern Bengal Railway, Calcutta, for 43 locomotive boilers, noted on pages 554 and 690 of our last volume, we now learn that the opening date of the tenders has been further postponed until February 12. (T. 27,813/39.)

Lifts.—We have been informed that the closing date for the receipt of tenders for the goods and passenger lifts for the Bloemfontein Post Office, noted on page 664 of our last volume, has been extended to February 29, by the Union Tender and Supplies Board, Pretoria. (T. 29,496/39.)

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—The production of iron and steel remains at the peak and full activity at works is assured. The pressure for the delivery of commodities for Government needs is unabated and still absorbs the bulk of the output, but producers of certain descriptions of material are able to provide an increasing tonnage for general industrial purposes, and some slight expansion of ordinary commercial business can be reported. At the same time, the distribution of tonnage is kept under strict control.

Cleveland Iron Trade.—The supply of foundry iron continues to meet requirements, though Cleveland qualities are scarce. The output of Tees-side brands is still suspended and prospects of a resumption of the regular make are remote. North of England foundry owners are relying largely on Midland firms for foundry iron and deliveries from that quarter continue to be regular and ample. Continental foundry-iron prices remain on too high a level to tempt firms here to return to the use of foreign products. Merchants are now handling very little Cleveland pig, the stabilised quotations of which remain at the equivalent of No. 3 quality at 108*s.*, delivered within the Tees-side zone.

Hematite.—Business in East Coast hematite is quiet owing to the disinclination of makers to accept extensive orders. The large output is well maintained but falls rather short of current needs, with the result that the heavy tonnage accumulations at the blast-furnaces are appreciably decreased and producers are disposed to act with much caution. Confidence is expressed, however, that stocks and maintenance of output are ample for requirements for a long time ahead. Makers' own consuming departments are absorbing large and increasing tonnage and users, dependent on the market for supplies, are not only calling for full contract deliveries but are anxious to negotiate extensively on forward account. Deliveries to Sheffield, the Midlands and South Wales are on a substantial scale. Fixed prices are ruled by No. 1 grade of hematite at 124*s.* 6*d.*, delivered to North of England areas.

Basic Iron.—The nominal price of Tees-side basic iron remains at 101*s.* 6*d.*, but the whole of the make is passing into direct use at the producers' own steelworks.

Foreign Ore.—Foreign-ore consumers are comfortably placed as regards supplies and imports promise to come forward more regularly than for some time. Recent unloadings have been heavy.

Blast-Furnace Coke.—Transactions in Durham blast-furnace coke are few and small, local consumers having little occasion to buy and holders not being anxious to sell. The market values are based on good medium qualities at 29*s.* 2*d.* at the ovens.

Manufactured Iron and Steel.—Re-rollers are now receiving ample supplies of semi-finished iron and steel and are very busily employed. The local output of semies has been increased considerably and imports from the Continent are on a much improved scale. Finished-iron firms have a considerable amount of work on hand and finished-steel producers continue to run their plant at capacity. Sheet-makers have substantial orders to execute; manufacturers of shipbuilding requisites are very extensively sold and producers of all kinds of heavy steel have as much work as they can handle. Among the principal market quotations for home trade are: Soft steel billets, 8*l.* 7*s.* 6*d.*; hard steel billets, 9*l.* 10*s.*; steel ship, bridge and tank plates, 11*l.* 10*s.* 6*d.*; joists and sections, 11*l.* 8*s.*; boiler plates, 12*l.* 8*s.*; black sheets, No. 24 gauge, 16*l.* 2*s.* 6*d.*; and galvanised corrugated sheets, No. 24 gauge, 18*l.* 12*s.* 6*d.*

Scrap.—Iron and steel scrap is somewhat less scarce than of late, but all available supplies continue to be promptly absorbed.

THE LATE MAJOR W. H. DICK.—It is with regret that we note the death, at his home in Gosforth, on January 9, of Major W. H. Dick. He was well known in Newcastle-upon-Tyne, and was for many years managing director of Messrs. Wailes Dove Bitumastic, Limited, Hebburn-on-Tyne. Born at Newcastle in 1880, and educated at Marchbank School and at George Watson's College, Edinburgh, he joined the firm of Messrs. Holzapfel (now Messrs. International Paint and Compositions Company) as a young man. For this company, the founder of which was his brother-in-law, he travelled extensively, and established valuable connections in various parts of the world. In 1911, he joined Messrs. Wailes Dove Bitumastic, Limited, as a director, ultimately taking over the entire management. During the war of 1914-18 he served in the Royal Engineers, was made a staff officer, and retired with the rank of major. At the outbreak of the present war, he was appointed deputy divisional commander of the Northumberland County Special Constabulary, but, unfortunately, was prevented from taking a very active part owing to illness.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—Writing in the January number of *The P.D. Review*, the official journal of the Powell Duffryn Associated Colliery Company, Limited, Mr. Edmund L. Hann, chairman of the company, expressed an optimistic view of the future of the British coal-mining industry. He stated that with the outbreak of the war they had encountered a period of abnormal conditions but what was gratifying was that the coal trade had never been so well organised or so efficient as it was to-day and, consequently, they looked forward to the future with greater optimism, particularly in regard to the bunker trade, which still remained the chief outlet of exported steam coals, than had been possible or justified for some years. He pointed out that even before the outbreak of war the drift away from coal to oil as fuel for vessels had been noticeably checked. Operations on the market proceeded along brisk lines throughout the past week. Buyers, both in the home and foreign sections, were displaying a keen interest, but the amount of business that could be concluded remained restricted. As a rule, offers for early delivery were confined to occasional parcels. Usually, sellers could dispose of these without much difficulty and with stem lists, particularly for the more popular sorts, well filled for some months to come, the general tone was very firm. Duff coals, especially, were scarce and strong, while sized and all large qualities were well placed. Smalls were not very plentifully available. Cokes and patent fuels were busy.

The Iron and Steel Trades.—Active conditions ruled in the iron and steel and allied trades of South Wales and Monmouthshire last week. The demand was good for all products, but order books were well filled ahead and, consequently, business could not be easily arranged. Most works were engaged to almost full capacity.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Though melting plant has been extended considerably during the past few months, the demand is outstripping production, and many works report the steady accumulation of orders. All types of steel are in demand, including stainless and rustless varieties, and also cutting and abrasion-resisting materials. Extensions are taking place at nearly all the producing works. Bigger supplies of scrap are coming forward, but these are quickly consumed. Sustained activity persists in the heavy-machinery and engineering branches. The demand for steelworks and ironworks machinery has been maintained. Local works expect to benefit considerably from orders to be placed by the Ministry of Supply for locomotives, rolling stock, materials for permanent way, freight tender engines, and covered goods wagons. There is a steady run on electrical plant; at least one Sheffield firm is maintaining exports to Shanghai, India, and South Africa. Petrol restrictions have resulted in a stronger demand for electric vans. Another progressive section is that devoted to the production of agricultural machinery and parts. Seasonal orders are well up to the standard of previous years on inland account, and makers anticipate a big influx of orders during the next few weeks. Makers of engineers' small tools are operating to capacity.

South Yorkshire Coal Trade.—Greater tonnages of coal are being consumed on inland account, industrial concerns taking heavy supplies; electricity and gas works are also good customers. The former are absorbing record tonnages as a result of the heavy demand for current for industrial purposes. There is also a brisk demand for house coal. The export position has undergone little change.

TAPERED-ROLLER BEARINGS FOR MACHINE TOOLS.—An excellent example of the modern catalogue, which concerns itself with imparting knowledge of design rather than with merely listing the products of a firm, has been recently issued by Messrs. British Timken, Limited, Cheston-road, Aston, Birmingham, 7, under the title "The Application of Tapered Roller Bearings to Machine Tools." The numerous very clear sectional drawings, apart from illustrating the text, show how varied are the combinations of the tapered-roller bearing to meet the widely different conditions of speed, load, rigidity, thrust, and degree of operating accuracy obtaining in the usual types of machine tools. The problems of lubrication and of spindle expansion in those machines which are almost continuously operated are dealt with, as also are those of protecting the bearings from the intrusion of dust and grit. Naturally, the methods employed in the manufacture of the Timken tapered-roller bearings are described, but it should be noted that as the publication is primarily a technical one and not intended for commercial use, data are not given of sizes stocked or standardised.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—In the Scottish steel trade the demand for steel of all kinds is on an unprecedented scale, but by careful arranging of deliveries, makers are managing to keep practically all their customers supplied. The makers of black-steel sheets have still a large amount of work on hand, so that only in exceptional cases can buyers expect early delivery; no falling-off in the present demand is anticipated. All the steelworks are running at top pressure and the output is on a very large scale. Prices are steady and are as follows:—Boiler plates, 12*l.* 8*s.* per ton; ship plates, 11*l.* 10*s.* 6*d.* per ton; sections, 11*l.* 8*s.* per ton; medium plates, 13*l.* 2*s.* 6*d.* per ton; black-steel sheets, No. 24 gauge, 16*l.* 2*s.* 6*d.* per ton; and galvanised corrugated sheets, No. 24 gauge, 18*l.* 12*s.* 6*d.* per ton, all delivered at Glasgow stations.

Malleable-Iron Trade.—The malleable-iron makers in the West of Scotland are still well employed and have a good tonnage of material on order. The re-rollers of steel bars, who have had an exceptional run, are still very busy, and although they have a large amount of work on hand, they have not been booking fresh business so freely of late. Some improvement in this direction is anticipated shortly as delivery of new orders is possible in two to three months. The supply of semies is satisfactory, as recent shipments have increased the stocks on hand. The following are the current quotations:—Crown bars, 12*l.* 15*s.* per ton; re-rolled steel bars, 12*l.* 19*s.* per ton; No. 3 bars, 12*l.* 17*s.* 6*d.* per ton; and No. 4 bars, 12*l.* 12*s.* 6*d.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—Great activity is general in the pig-iron trade of Scotland and every ton being produced is quickly taken up. The demand from the steel trade alone is very heavy. Hematite and basic iron move freely but more business would be welcomed in foundry grades. To-day's prices are as follows:—Hematite, 6*l.* 4*s.* 6*d.* per ton, and basic iron, 5*l.* 1*s.* 6*d.* per ton, both delivered at the steelworks; foundry iron, No. 1, 5*l.* 12*s.* per ton, and No. 3, 5*l.* 9*s.* 6*d.* per ton, both on trucks at makers' yards.

THE LATE MR. J. JUDSON.—The news of the death of Mr. John Judson, which occurred at his home in Pudsey, Yorks, on January 4, will be received with regret by many engineers in the West Riding of Yorkshire and elsewhere. Mr. Judson, who was engaged in the machine-tool industry throughout his career, was at one time a partner in the firm of Messrs. Judson and Jackson, of Westminster. In 1929, he joined the firm of Messrs. George Cohen, Sons and Company, Limited, 600, Commercial-road, London, E.14, and since 1933 had managed, most successfully, the firm's machine-tool department, having headquarters at Stanningley, near Leeds.

THE IRON AND STEEL INSTITUTE.—Subject to unforeseen circumstances, the annual general meeting of the Iron and Steel Institute will be held in London on Thursday and Friday, May 2 and 3. The programme and list of papers presented for discussion will be announced in due course. The date and place of the autumn meeting have not yet been fixed, but the Council proposes to arrange a meeting in September at which papers will be presented and discussed. Special meetings of the Institute may be held at suitable centres, and the Council hopes, with the collaboration of the Councils of local societies, to hold a number of meetings during the spring, in the South Wales, North-East Coast, and other districts. The offices of the Institute are at 4, Grosvenor-gardens, London S.W.1.

THE LATE MR. D. H. BAIRD, C.B.E.—We have learnt with regret of the sudden death, on January 3, at his home in Esher, Surrey, of Mr. Douglas H. Baird, chairman and managing director of Messrs. Baird and Tatlock (London), Limited, 14-17, St. Cross-street, Hatton Garden, London, E.C.1. Mr. Baird was educated at Charterhouse School, the University of London, and at Karlsruhe (under Engler), and joined his father, Mr. Hugh Harper Baird, in the firm of Messrs. Baird and Tatlock in 1901. Ten years later he was made chairman and governing director of the company, and, subsequently chairman and managing director of Messrs. Hopkin and Williams, Limited. During the war of 1914-1918, Mr. Baird was engaged entirely on Government work; he designed the first mobile bacteriological laboratory sent out to France and was responsible for improvements in this and for the planning of other special laboratories for the use of the allied army medical services. For this work he was created a C.B.E. in 1920. He was chairman of the British Chemical-Ware Manufacturers' Association, and a member of the Councils of the National Union of Manufacturers, and of the British Lampblown Scientific Glassware Association, Limited. He was also vice-chairman of the British Laboratory-Ware Association, a member of the Standards Committee of the Institute of Chemistry, and a member of the Royal Institution and of the Society of Chemical Industry.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTION OF MECHANICAL ENGINEERS.—To-day, 3 p.m., Storey's-gate, S.W.1. General Meeting. Twenty-Sixth Thomas Hawksley Lecture: "A Review of Forty Years' Development in Mechanical Engineering Plant for Power Stations," by Sir S. Leonard Pearce. A luncheon will be held at 1.15 p.m., at St. Ermins Hotel, Caxton-street, S.W.1. *London Graduates' Section:* Monday, January 22, 6.45 p.m., Storey's-gate, S.W.1. Discussion on "Patents." *South Wales Branch:* Thursday, January 25, 3 p.m., The South Wales Institute of Engineers, Cardiff. Chairman's Address: "Some Notes on the Development of the Steam Boiler," by Mr. H. F. Reeman. *East Midlands Branch:* Friday, January 26, 7 p.m., College of Technology, Leicester. "Cutting Tools," by Dr. G. Schlesinger.

JUNIOR INSTITUTION OF ENGINEERS.—*Midland Section:* Saturday, January 20, 2.30 p.m., The James Watt Memorial Institute, Birmingham. "Recent Developments in the Use of Town's Gas and Other Gases for Traction Purposes," by Dr. C. M. Walter. *Institution:* Friday, January 26, 6.30 p.m., 39, Victoria-street, Westminster, S.W.1. Informal Meeting. Lecture: "Forced Circulation Boilers," by Captain R. E. Trevithick.

INSTITUTION OF ELECTRICAL ENGINEERS.—*South Midland Centre:* Monday, January 22, 6 p.m., The James Watt Memorial Institute, Birmingham. Chairman's Address, by Mr. H. Joseph. *North-Eastern Centre:* Monday, January 22, 6.15 p.m., The Newe House, Pilgrim-street, Newcastle-upon-Tyne. "Operating Experience with High-Voltage Alternators," by Mr. W. D. Horley. *East Midland Sub-Centre:* Tuesday, January 23, 6 p.m., The Electricity Showroom, Derby. Chairman's Address, by Mr. S. J. R. Allwood. *Scottish Centre:* Tuesday, January 23, 6.30 p.m., The Royal Technical College, Glasgow. Chairman's Address, by Professor S. Parker Smith. *North-Western Centre:* Tuesday, January 23, 6.45 p.m., The Engineers' Club, Manchester. "The Maintenance of Relays and Associated Equipment," by Mr. J. R. Brookman, to be presented by Mr. H. G. Bell. *Institution:* Thursday, January 25, 6 p.m., Savoy-place, Victoria-embankment, W.C.2. Ordinary Meeting. Discussion on "Fire-Fighting Equipment for Electrical Installations," to be introduced by Messrs. H. W. Swann, J. Hacking and R. A. McMahon. *Irish Centre:* Thursday, January 25, 6 p.m., Trinity College, Dublin. Chairman's Address, by Dr. T. A. McLaughlin. *North Midland Centre:* Saturday, January 27, 2 p.m., The Hotel Metropole, King-street, Leeds. "The Applications and Limitations of the Inverse-Time Overload Relay to the Protection of an 11-kV Network," by Messrs. J. W. Gallop and R. H. Bousefield.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, January 23, 6.30 p.m., 39, Elmbank-crescent, Glasgow, C.2. "Effect on the Propulsion of a Single-Screw Cargo Vessel of Changes in the Shape and Dimensions of the Propeller," by Messrs. J. L. Kent and R. S. Cutland.

ROYAL INSTITUTION.—Wednesday, January 24, 5.15 p.m., 21, Albemarle-street, W.1. "Theory of Nuclear Forces," by Professor R. Peierls. Friday, January 26, 5 p.m., "Long Distance Broadcasting," by Sir Noel Ashbridge.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Student Section: Wednesday, January 24, 6.45 p.m., Bolbec Hall, Newcastle-upon-Tyne, 1. "Steam Turbines for Merchant Ships," by Messrs. J. E. S. Fraser-Smith and P. J. Daglish. *Institution:* Friday, January 26, 6 p.m., The Mining Institute, Newcastle-upon-Tyne. "Propulsion Scale Effect," by Dr. W. P. A. van Lammeren.

INSTITUTE OF FUEL.—Thursday, January 25, 2.15 p.m., Institution of Mechanical Engineers, Storey's-Gate, S.W.1. "Pool Grades of Gas, Diesel and Fuel Oils," by Messrs. N. L. Hudson, R. J. Bressey and T. C. Bailey.

INSTITUTE OF PETROLEUM.—Friday, January 26, 3.15 p.m., The Royal Society of Arts, 18, John-street, Adelphi, W.C.2. Presidential Address, by Professor A. W. Nash.

INSTITUTION OF AUTOMOBILE ENGINEERS.—*Sheffield Centre:* Friday, January 26, 6 p.m., The University St. George's-square, Sheffield. "Deep Drawing Research," by Professor H. W. Swift.

MANCHESTER ASSOCIATION OF ENGINEERS.—January 26, 7.15 p.m., The Engineers' Club, Manchester. "Equipment for Handling Lock Gates, Salvage Work and Heavy Traffic Lifts on the Manchester Ship Canal," by Messrs. W. G. Smith and R. Parker.

INSTITUTION OF PRODUCTION ENGINEERS. *Yorkshire Section:* Saturday, January 27, 2.30 p.m., The Hotel Metropole, Leeds. Lecture: "Grinding Wheels," by Mr. A. Pearson.

ERECTION OF ANCHOR AND NAVIGATION SPANS, STORSTROM BRIDGE.

(*For Description, see Page 53.*)

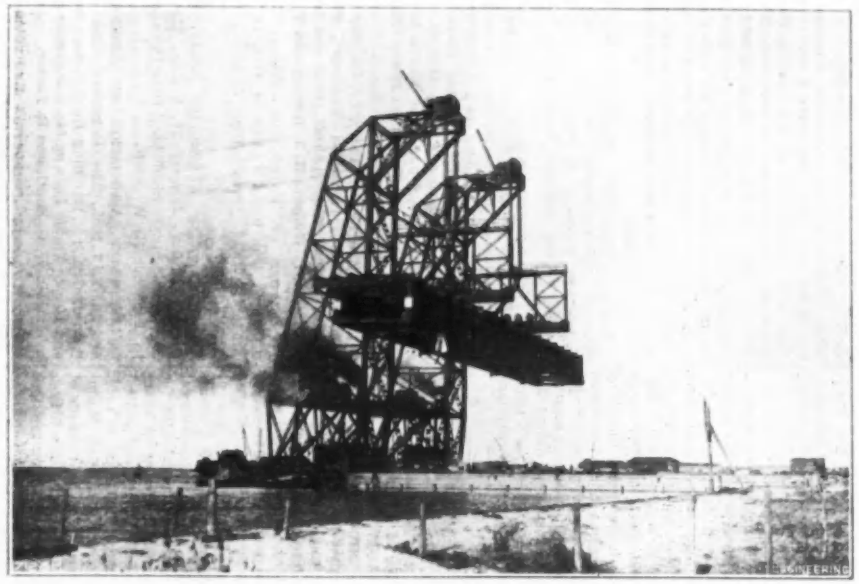


FIG. 30. FLOATING CRANE LIFTING ANCHOR SPAN.

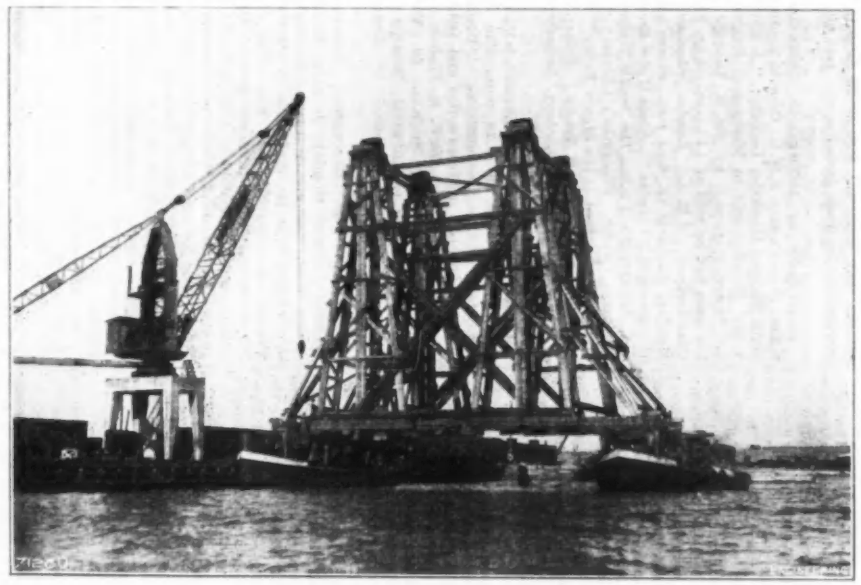


FIG. 31. NAVIGATION-SPAN TRESTLE.

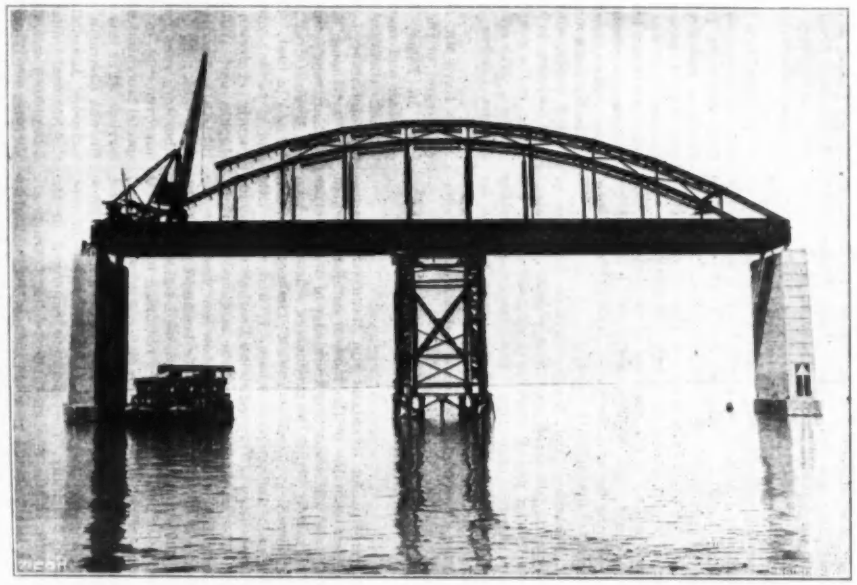


FIG. 32. FIRST NAVIGATION SPAN APPROACHING COMPLETION.

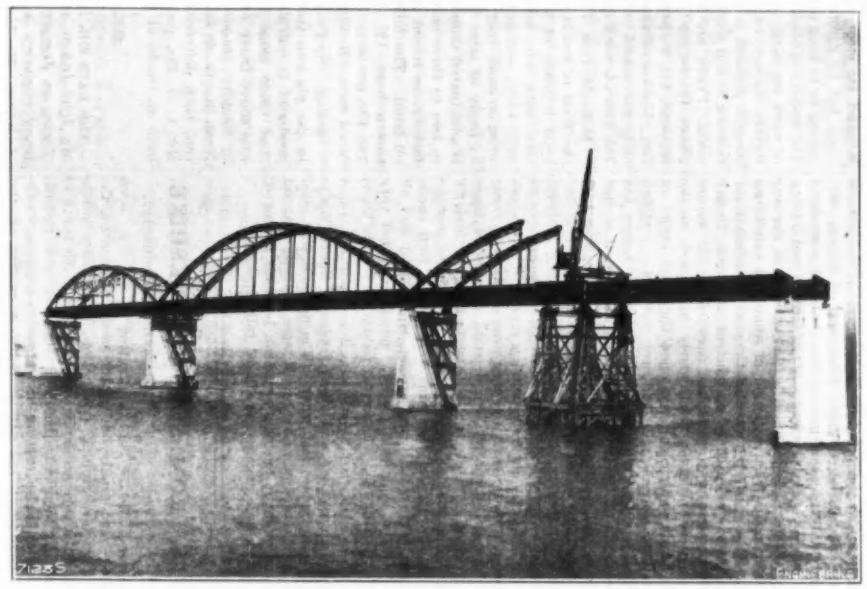


FIG. 33. THIRD NAVIGATION SPAN UNDER CONSTRUCTION.

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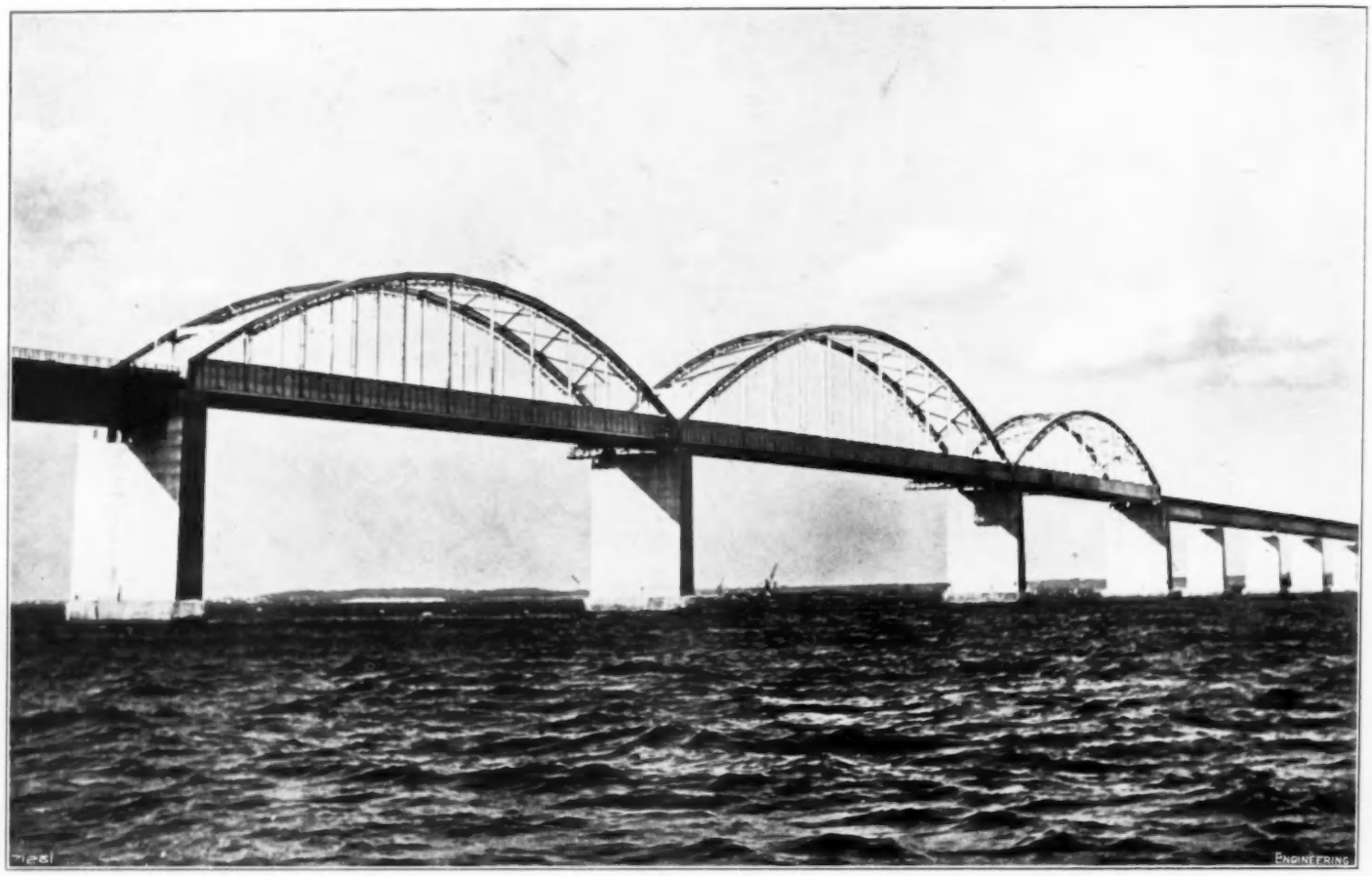

FIG. 17. VIEW OF THE THREE NAVIGATION ARCHES, STORSTROM BRIDGE.

FIG. 18. GENERAL VIEW OF STORSTROM BRIDGE.

UNIV. OF MICH.

HASMUNDSUND BRIDGES, DENMARK.

(For Description, Page 53).

FIG. 19. OLD AND NEW MASNEDSUND BRIDGES.

FIG. 20. ERECTION OF CENTRE NAVIGATION SPAN, STORSTROM BRIDGE.

FIG. 21. VIEW THROUGH NAVIGATION SPANS, STORSTROM BRIDGE.

UNIV. OF

ENGINEERING.

Offices for Publication and Advertisements, 35 & 36, Bedford Street, Strand, London, W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and other publications bearing somewhat similar titles.

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When foreign subscriptions are sent by Post Office Orders, advice should be sent to the Publisher.

ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines, or under, and one shilling per line up to one inch. The line averages six words. When an advertisement measures an inch or more the charge is 12*s.* per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns, of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of Publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

All accounts are payable to "ENGINEERING," Ltd. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730, and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

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SOME RECENT RESEARCHES IN WELDING.

WAR circumstances press hardly upon the technical staffs of inspecting and classification societies, such as the shipping registers and the engineering insurance companies, the volume of whose work inevitably increases, while the facilities for carrying it out are liable to be simultaneously reduced. Under such conditions, the continued production of the reports and scientific investigations, which form such a valuable feature of the peace-time activities of these organisations, must be somewhat curtailed. The decision of the British Engine, Boiler and Electrical Insurance Company, to suspend publication of their complete technical report for 1938, is not surprising, therefore, but we note with satisfaction that they have made an exception in respect of certain articles dealing with welding in which subject, they rightly consider, there is no lack of interest at the present time. The shortened report, embodying three researches on welding and two investigations of service failures, emphasises the importance of a sound knowledge of the metallurgy of welding if the full advantages of fabricated construction are to be achieved. At the same time, it is recognised that the engineer's contribution to the development of welding technique can be of great value, not least when desirable methods of works' practice raise welding problems the investigation of which extends metallurgical knowledge.

A case exemplifying this latter aspect was the subject of an investigation to determine whether any disadvantage was likely to result from preparing mild-steel plates for welding by means of flame cutting. For this purpose, three series of tests were conducted using 1-in. boiler plate of 28 tons to 32 tons per square inch quality, attention being specially directed to the possibly harmful effects of oxide scale left by extreme conditions of the cutting flame, and to the comparison between flame-cutting by hand and by machine. For the first tests several butt welds were made, each having one edge scarfed by planing and the other scarfed by flame-cutting, the effects of excessive proportions of acetylene and of oxygen in the torch being studied for comparison with those produced by a normal flame. A second set of butt welds was prepared with both scarfs bevelled by the same method, either by normal flame-cutting or by planing. Oxide scale on the flame-cut edges was carefully preserved in position, and welds were made with bare wire and with rods coated alternatively with acid slag and basic slag, the intention being to observe any effects of different types of electrode. This experiment was extended by the third series of tests, in which the metallurgical conditions of flame-cut edges were examined with reference to the heat of subsequent welding and the nature of the electrode coating. The general outcome of a comprehensive study of all these welded samples, by metallurgical and mechanical tests, has been to show that welds can be prepared by flame-cutting without significant detriment to the resulting welds. The scale can be effectively floated off by a suitable flux covering on the electrode, and the hardness of the welded edges is not increased by previous flame-cutting. Particularly noteworthy is the conclusion that the rough edges left by flame-cutting by hand are entirely melted away by the welding, leaving a welded profile as smooth as that of edges prepared by machining. This result applies generally, provided the welding rod gives good penetration, and there seems no obvious reason why flame preparation should not be used for plates more than 1 in. in thickness. For the highest grade of workmanship, nevertheless, it will no doubt be preferred to use mechanical flame-cutting, or at least to grind off the deeper irregularities due to hand flame-cutting and to remove loose scale prior to welding.

The more fundamental character of the company's metallurgical work is represented by a research into certain effects of heat treatment upon the microstructure of metallic-arc welded parts. This work has been more especially concerned with structural changes due to the precipitations or absorptions of nitrides after heat treatments at various temperatures. It acquires practical importance from the possibilities that embrittlement may arise from the presence of nitride needles, as experiences of basic-Bessemer steels, working at elevated temperatures, seemed to indicate; and that variations in the rate of cooling of a weld, after the commonly applied stress-relieving heat treatment at 600 deg. C., are now shown to exert a marked influence on the extent to which nitrides are precipitated out of solution. Briefly, the research may be said to have established that, except for highly-contaminated weld metal, the nitride does not settle out of solution at temperatures above 300 deg. C., and that precipitations may take place after prolonged tempering at temperatures as low as 100 deg. C. The slower the rate of cooling, of course, the greater will be the opportunity for precipitation of nitrides to occur. Hence the conclusion is reached that, when a weld metal subject to ageing is given a works treatment, a rapid rate of cooling to atmospheric temperature tends to improve toughness. The possibility must not be overlooked, however, that such metal may subsequently age and deteriorate by prolonged exposure to the lower ranges of steam temperature, and that such tendency will not be detected by tests before service. If, on the other hand, the works treatment is followed by a low rate of cooling, it may be expected that there will be less liability for the toughness of the metal to fall below pre-service test figures during its useful life at elevated temperatures.

A matter of considerable potential value to engineers is the demonstration by the company's research staff that a certain proprietary process of depositing a single-run electric-arc butt weld can produce excellent mechanical properties even though the metal is unrefined. The test results on a weld in 1½-in. mild-steel plate were, in fact, considered well up to accepted standards for refined weld metal. Details of the process are not disclosed in the report, but a striking feature is the great depth of run, which apparently leads to a tendency for dendrites in the deposited metal to grow away

from the prepared faces of the welding Vee, gradually assuming a vertical direction as they approach the centre of the weld. This dendritic macrostructure, clearly revealed after an annealing treatment at 620 deg. C., is almost entirely eliminated by normalising at 940 deg. C. Even when the weld is only annealed, however, the Izod value at room temperature for any part of the weld is appreciably above the figure of 30 ft.-lb., commonly specified for a high-grade weld. It must be realised, of course, that if these good qualities are to be achieved in practice, precautions are necessary to ensure that the metal can be laid without causing contraction cracks, excessive hardening of the parent metal or excessive distortion of the parts being welded. Conditions likely to promote increased coarseness of the dendrites or severe chilling of the molten metal are similarly to be avoided, while special consideration is naturally required if the parent metal has self-hardening properties.

In view of such qualifications as these, indicating the possibilities of error surrounding the welder on every hand, it is not astonishing that circumstances occur in which he can unwittingly cause damage outside his own proper sphere of activity. An example of this sort, cited in the report, was recently disclosed by the examination of some large steam pipes which had failed after about five years' service. The failures were discovered to be due to local cracks, in metal of highly satisfactory quality, radiating in star formation from small globules of weld metal. It was evident that these defects owed their origin to the welding operator who, while engaged in joining flanges or branches, had from time to time struck the surface of the pipe with his electrode in order to break off the slag. The hot weld metal, deposited on a cold, good-conducting surface, initiated contraction cracks which gradually extended to the steel of the pipe and eventually led to failure by penetrating, in some cases, the full thickness of the wall.

Engineers may well be grateful for having a dangerous, yet easily overlooked, practice of this sort brought to their attention. Equally, they can appreciate the technical ingenuity with which, for instance, notched-bar impact tests were made on tiny specimens cut from the heads of rivets which failed in a Lancashire boiler. It is not too much to say that investigatory work of this kind, characterised throughout by skill and knowledge, is not less valuable, in the long run, than the assurance of added safety in operation by means of regular surveys of plant, which was the initial reason for the establishment of the inspecting organisations that have contributed so materially to the high repute of British engineering.

ERNST ABBE, 1840-1905.

ON Tuesday, January 23, occurs the centenary of the birth of the German mathematical physicist whose labours contributed so greatly to the development of the famous Zeiss optical works at Jena.* Many firms have owed their success to the collaboration of men of diverse talents and attainments, but the story of the Jena works is one of the most striking examples of the benefits to an industry of the original investigations of a man of science.

The founder of the firm at Jena was Carl Zeiss who was born in 1816 and died in 1888. The son of a toy maker at Weimar, he was trained as a mechanic, and, after working in various cities, set up for himself at Jena in 1846, becoming instrument maker to the university. Among the staff of the university at this time was Professor Matthias Jakob Schleiden (1804-81), the botanist, whose name is connected with the enunciation of the cell theory. Through Schleiden, Zeiss was led to try to improve the construction of microscopes, but, not being acquainted with the mathematical theory of light, he appealed to Abbe, then in his twenty-seventh year. Abbe was born at Eisenbach and from his school days had shown unusual talent. He had studied at Jena and Göttingen, and taught at Frankfort before he returned, in 1863, to Jena as a *Privatdozent* in mathematics, physics and astronomy. When approached by Zeiss, he had no hesitation in co-operating in the task suggested, and, by 1870, had discovered what is known as Abbe's theory of microscopic vision. In that year, he was made an extraordinary professor in the university, but much of his time was taken up with the Zeiss business of instrument-making, in which he became a partner in 1875. In 1876, he visited London to inspect the Loan Collection of Scientific Instruments at South Kensington, some of the exhibits from which are now preserved in the Science Museum. In his report on the collection, he wrote that "The future of the microscope as regards further improvement in its dioptric qualities seems to be chiefly in the hands of the glass maker."

There is an element of romance about the history of glass for optical purposes. One of the greatest improvements in optical instruments was made by John Wallond, the son of a French refugee in London, when, in 1757, he constructed achromatic telescopes having lenses of both crown and flint glass, the latter being a British invention and a monopoly of British glass makers. This invention was one of the factors which made our instruments the finest in the world. Towards the latter part of the Eighteenth Century, an obscure Swiss clock maker, Pierre Louis Guinaud (1748-1824), stimulated by the possession of an achromatic telescope, made a long series of experiments, which, though they impoverished him, enabled him at last to produce discs of flint glass equal to any obtainable elsewhere. His methods of manufacture are practically those used to-day.

When Napoleon had closed the frontiers of the Continent and optical glass could no longer be obtained from England, Guinaud carried his secrets to the workshops of Fraunhofer, at Munich, where he resided from 1805 to 1814, enabling Fraunhofer to construct some very notable telescopes. Optical glass was still far from perfect, however, and among later experiments were those made by Faraday and Canon H. V. Harcourt, a founder of the British Association. Twenty years after his death, Guinaud's process of glass-making was introduced in this country by Messrs. Chance, of Birmingham, who had secured the services of a French glassmaker, George Boutemps, and by the time of the Great Exhibition of 1851 some remarkable discs had been produced. From that time onwards, until Abbe began his work, little improvement was made, but his report on the 1876 Collection of Instruments had effects as far-reaching as the work of Guinaud. The report was read by Otto Schott, a glassmaker of Witten in Westphalia, and in 1881 he began to correspond with Abbe. In the following year, he moved to Jena to establish a works and laboratory, and in 1883 the German Government granted a subsidy of 3,000*l.* towards the experiments. When the subsidy was under discussion, the famous German biologist, Rudolf Virchow, then a member of the Reichstag, pointed out that the manufacture of optical glass was a matter of national importance, for hitherto Germany had been dependent upon foreign countries for the glass for instuments for military and naval purposes.

The joint labours of Schott and Abbe soon bore fruit, and in 1886 the first catalogue of the Jena Glass Works was issued. In this it was said that "The industrial undertaking here first brought into public notice, and which has arisen out of a scientific investigation into the dependence between the optical properties and the chemical composition of solid amorphous fluxes was undertaken by the undersigned [Schott and Abbe] in order to discover the chemico-physical foundations of the behaviour of optical glass"; so came into existence the famous "Jena glass." By 1888, nearly all the glass for optical work in Germany was of home manufacture. By the end of the century there was an export trade of raw glass to the value of about 30,000*l.*, and the annual value of the telescopes, field glasses, spectacles, etc., sent abroad was nearly 250,000*l.* German thermometers, too, had penetrated the markets of the world.

Abbe is not only remembered for his contributions to this great industrial development, but as a philanthropist. Zeiss having died in 1888, and his son retiring shortly afterwards, Abbe became the head of both instrument and glass works, which in 1891 he turned into a form of trust called the "Carl Zeiss Stiftung," to which he ceded all his proprietary rights. Assisted by other able men of science, Abbe continued to direct the works until 1903, when he retired through ill health. Two years later he died, ten days before his sixty-fifth birthday. Almost immediately after his death, steps were taken to erect a permanent memorial to him, and to-day his statue stands in the hall of the university, and a bust can be seen in the beautiful Abbe-Tempel in the centre of the city he served so well. No one had a higher opinion of Abbe's work than the late Sir Richard Glazebrook, whose address to the Optical Convention of 1905, held five months after Abbe's death was reprinted in our columns.*

* See ENGINEERING, vol. 126, page 665 (1929).

* See ENGINEERING, vol. 79, page 722 (1905).

NOTES.

DUNLOP SCHOLARSHIPS.

THE question of the employment of youths between leaving school and the attainment of military age, which has been raised by Lord Derby, has been generally realised to be of great importance. The exigencies of the time will interrupt the higher education or business training of a very large number of young men, and it is to be hoped that, when the present conditions have passed, we shall not be in the position we were at the end of the last war, when we had large numbers who had reached an age at which it was difficult to make a new start and yet whose pre-war training had left them with no adequate claim for employment in the line of work on which they had originally set out. As recruitment this time is on a more orderly basis, the problems of the future may not be those of the past, but, from the points of view both of fairness to the individual and the welfare of the nation, everything possible should be done to enable young men to take their future place in civil life without a handicap imposed by their performance of the greatest service they can make for their country. The matter raised by Lord Derby is clearly a difficult one, as firms and organisations of all kinds must, in a period of stress, feel some diffidence about employing young people who will leave their service at just about the time when they are becoming of some value, and whose training must add to the responsibilities of a probably already overworked staff. An example of what can be done, however, has been set by Messrs. The Dunlop Rubber Company, which has instituted a series of Dunlop Scholarships designed to aid young men to acquire, in the period between school and the army, some commercial training which is likely to serve them well in the future. The scholarships, which include a maintenance grant of 52*l.* a year, cover training under expert supervision. The Dunlop Company has a permanent scheme for the selection and training of young men for its service, but this is restricted to those who have entered its employment in a normal way and who have been with the firm for a period exceeding one year. This training will now be available for those who are awarded the scholarships. The training, which will be carried out at the company's works at Fort Dunlop, and at their various branches, will include a period in which some experience will be obtained in the manufacturing and research departments, after which sales accounting, branch management, advertising, office methods and similar commercial subjects will be studied. Although the company cannot undertake to find employment for these pupils after the termination of the course of instruction, it is pointed out that, given satisfactory trading conditions, the possibility of permanent employment may exist later. Those awarded scholarships must be from 17½ years to 19 years of age at the commencement of the course, and must have reached an educational standard equivalent to matriculation; they must be of British nationality and in sound health. Forms of application can be obtained from the Personnel Officer, Dunlop Rubber Company, Limited, Fort Dunlop, Birmingham. When being filled in, the forms must be signed by the candidate's parent or guardian, to indicate that the application is made with his approval. A letter of recommendation from the

head master of the school last, or at present, attended is also required. It may be hoped that this useful contribution towards the solution of a difficult problem may be followed by others.

THE OPERATIONS OF THE MINISTRY OF SUPPLY.

The work of the Ministry of Supply in ensuring an adequate provision of the raw materials necessary to the nation's war effort was strikingly summarised by Colonel J. J. Llewellin, M.P., Parliamentary Secretary to the Ministry, at a Press conference held on January 11. Before the war, stated Colonel Llewellin, the intended organisation of raw-materials supply had been very fully investigated and planned by the Board of Trade in order that the necessary controls should be established without loss of valuable time in the event of hostilities. On August 1 this organisation was transferred *en bloc* to the Ministry of Supply. The plans embraced not only the anticipated needs of the Services, but also the stocks, and the distribution of them, necessary to facilitate the change-over of industry from a peace to a war footing, and to maintain it in working order in the event of intensive air attack on inland communications. The Government commenced at once to acquire stocks of aluminium, zinc, antimony, mercury, ferro-alloys, phosphate rock, mica, sulphur, etc., and to speed up the production of such materials, where this was requisite and practicable, throughout the Empire. The results attained in this direction are interesting in comparison with the outputs available at the outbreak of war in 1914. The production of copper ore, for example, has increased from 85,000 tons per annum to 600,000 tons; that of lead ore, from 130,000 tons to 630,000 tons; nickel, from 20,000 tons to 95,000 tons; aluminium, from 13,900 tons to 88,000 tons; and asbestos, from 98,000 tons to 344,000 tons. Since the war started, continued Colonel Llewellin, the purchases handled by the Ministry had expanded to a rate of 150,000,000*l.* per annum, and it now owned all supplies in the country of aluminium, copper and other non-ferrous metals, wool, flax, most kinds of fertilisers, and molasses. Arrangements had been made to buy the whole wool clip of Australia and New Zealand, for the duration of the war, and for one year afterwards, at a price only 30 per cent. above the pre-war rate. The Government purchases of wool in the last war, he added, were bought at an advance of 55 per cent. over the 1914 pre-war price. The copper, lead and zinc had been bought at prices less than the present ruling world figures. The Ministry had acquired all the surplus supplies of wolfram from Australia, Burma, New Zealand and some foreign countries. The productive capacity of British steelworks was 75 per cent. greater than it had been in 1914, and the Empire production had increased in the same period from one million to four million tons per annum. The total productive capacity, domestic and Empire, had been developed from 9 million tons to 18½ million tons of steel per annum. All purchases required for the needs of both Great Britain and France were made through an Anglo-French committee, to avoid wasteful competition between the two nations for essential supplies. The aims of the Ministry of Supply, Colonel Llewellin said, in conclusion, were to maintain essential stocks, to buy at the best prices and to avoid violent fluctuations in price, to sell at prices fair to both the taxpayer and the consumer, and to distribute the available stocks to the best purpose. The Ministry could claim that it was succeeding in its task.

ROAD ACCIDENTS AND THE BLACK-OUT.

During last week end 2,000 bombs were dropped on the cities of South Finland by Russian aircraft, by which 18 persons were killed and 93 wounded. These figures show that though the damage to property may be severe, the risk to life from this form of warfare is comparatively small; and may be compared with the number of fatalities which occurred on the roads of Great Britain during December, 1939. These amounted to no less than 1,155, which is the highest ever recorded. In September, 1939, the first month of the war, 1,130 persons were killed, but the numbers fell to 919 and 926 in October and November, respectively. Assuming, for the sake of argument, that the air raids in Finland continued for a month with the comparable results to those just mentioned, a simple mathematical calculation will show that about 180 persons would be killed, or, roughly, one-sixth of the number who have suffered death on the roads of this country, not by the hand of the enemy, but by the vehicles of their fellow citizens. That this result is due in great part to the policy of extinguishing all street lighting is shown by the fact that of the total number of fatalities as many as 895 occurred during the hours of darkness, which, of course, reached their maximum in December. If this factor were the sole cause of what has happened, it is hardly likely to be much improved by the system of "darkness visible," which the lighting authorities are now being allowed to instal in the streets. A change for the better, therefore, only can be brought about in two ways: by a resumption of normal street lighting, a course against which the Government have so far set their faces, or by a much greater control of drivers of motor vehicles, cyclists and pedestrians. The last are the principal sufferers, constituting no less than 820 of the 1,155 fatalities; the cyclists numbered 129 and motor drivers only 44.

LIFT ACCIDENT ON THE MERSEY RAILWAY.

A lift accident which appears to present some unusual features occurred at Birkenhead on Wednesday, January 10, at the Hamilton-square station of the Mersey Railway. Shortly after 5 p.m., when the evening traffic peak was just beginning, one of the two hydraulic lifts started without warning and descended rapidly to the bottom of the shaft. It struck the rest blocks with considerable violence, causing shock or injury to nearly 60 people, 19 of whom were detained in hospital. The lift was being loaded at the time and the attendant, standing immediately outside the open doors, was left behind in the booking hall. There was another attendant, however, on duty at the lower level, some 87 ft. below the street, and he was able to open the lower-landing doors and initiate the work of rescuing the injured. No official statement has been made, which might indicate the proximate cause of the accident, but an investigation was immediately begun by the Ministry of Transport. The lifts are of the direct-acting type and of unusually large size, each holding 100 persons, and have been in public use for almost exactly 54 years, January 20 being the anniversary of the opening of the railway in 1886. Descriptions of the Mersey tunnel and the other engineering features of the line, including the lifts, appeared in the 41st volume of ENGINEERING. Three similar lifts were provided at James-street station, Liverpool, but two of these were replaced by electric lifts in 1936. The accident is the first of any consequence since the railway was opened.

THE DIESEL ENGINE USERS ASSOCIATION.

A FIFTIETH anniversary which falls in 1940 is the dual one of Herbert Akroyd Stuart's patents No. 7146, of May 8, and No. 15994 of October 8, 1890. The first covered an automatic-ignition engine with air admission into a vaporiser and timed injection at the end of the compression stroke; and the second patent described the modified form subsequently to become known as the Hornsby-Akroyd engine. A luncheon to celebrate this important anniversary in the history of the internal-combustion engine was held by the Diesel Engine Users Association at the Connaught Rooms, London, W.C.2, on Thursday, January 11, under the chairmanship of the President of the Association (Mr. George E. Windeler, M.I.Mech.E.). The luncheon was followed by a meeting of the Association, over which Mr. Windeler also presided, to hear and discuss a paper entitled "Herbert Akroyd Stuart and the Development of the Heavy Oil Engine," by Mr. T. Hornbuckle, B.Sc., A.M.Inst.C.E. (past-president), and Mr. A. K. Bruce, M.I.Mech.E. (member of Council). We commence to reprint the paper on page 70 of this issue.

In proposing a toast "To the Memory of Herbert Akroyd Stuart," the President said that Akroyd Stuart's patent had established an engine type throughout the world over a very considerable period of time, and even to-day parts of his patents were incorporated in many well-known and successful high-speed Diesel engines. He also suggested pilot oil ignition. Even after he had left the British Isles, he continued his interest in the internal-combustion engine, introducing it to the mining industry of Western Australia; and he had a good deal to do with the initiation and development of the down-draught gas producer.

The toast having been honoured, the President announced the opening of the Association's meeting, first making a presentation, to Mr. W. R. Holland and Mr. F. Fitchett, of the Percy Still Medals, awarded to them for a joint paper on "The Design and Construction of Alternators for Coupling to Diesel Engines." The minutes of the previous general meeting, held on December 14, 1939, having been read, confirmed and signed, he proceeded to introduce the authors of the paper, observing that he had corresponded with Akroyd Stuart when the latter was living in Australia, and considered it very appropriate that the Diesel Engine Users Association should be the channel for a discussion of Akroyd Stuart's achievements and their effect on the oil-engine industry.

Mr. A. K. Bruce, who presented the paper to the meeting, remarked that the work of Sadi Carnot had been commemorated in France in 1926; the sixtieth anniversary of the first Otto four-stroke gas engine had been celebrated in Cologne in 1936; the fortieth anniversary of the testing of the first Diesel engine was marked by elaborate ceremonial at Augsburg in 1937, and, in 1938, the enunciation of the four-stroke engine, by Beau de Rochas, had been suitably honoured in France. The present meeting was intended to recognise the work of the Englishman (of Scottish extraction), Herbert Akroyd Stuart. The paper had been prepared with the object of assessing the historical value of his work and not with the idea of claiming for him, as an inventor, anything to which he was not entitled. The publicity given to the Diesel engine had been such that practically all heavy-oil engines were popularly called "Diesel" engines. They did not disparage the great impetus given to the heavy-oil engine by Dr. Diesel's work; the present type of engine had descended from a plurality of parents, but they could not conveniently call it a "Carnot-Beau de Rochas-Akroyd Stuart-Diesel" engine, although each of these pioneers had had a hand in it. He hoped that the discussion might produce suggestions for a more appropriate nomenclature.

Wing-Commander T. R. Cave-Browne-Cave, who was invited by the President to open the discussion, said that the question of the relative contributions of Akroyd Stuart and Diesel was particularly difficult, because so much of the evidence depended on verbal statements of fairly long recollection. Without contemporary documentary evidence, verbal statements should be accepted with caution. Mr. Bruce referred to the destruction of Akroyd Stuart's papers, in accordance with the terms of his will. Why should he have stipulated that these important records must be destroyed? Perhaps because he felt that they formed a very unsatisfactory and incomplete record, and did not wish them to be accepted as complete when they were not. His great contribution was that he put in the air and the fuel separately; but as to the question of ignition, Wing-Commander Cave considered there was some doubt—for his own part, he thought that ignition was due to the heated cylinder end, and not solely to compression. Was compression ignition really the contribution of Akroyd Stuart or of Diesel? If Akroyd Stuart had been able to solve his ignition problems by using a sufficiently high compression, the compression-ignition heavy-oil engine might have led the petrol engine, instead of vice versa.

Mr. H. V. Senior thought that the paper offered few controversial points. The term "Diesel engine," as commonly used, was a misnomer; the air-injection engine, which was the real "Diesel" engine, died a natural death a few years ago, whereas most compression-ignition engines now used Akroyd Stuart's principle. This fact should be given every publicity, because the lay mind to-day

EARLY AKROYD STUART OIL ENGINES.

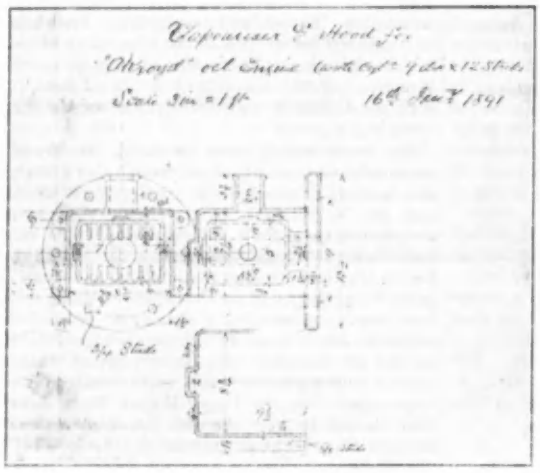


FIG. 1.

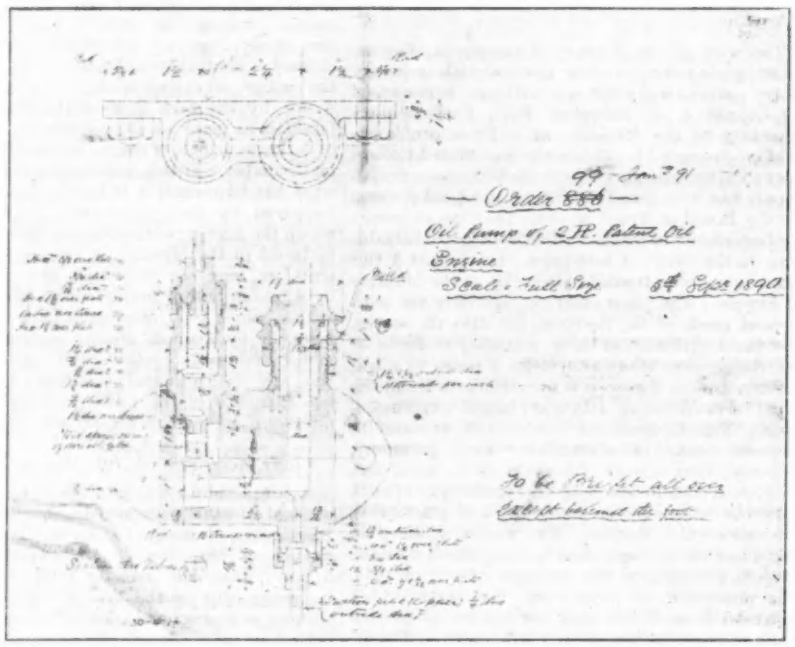


FIG. 2.

held the impression that the high-speed oil engine for transport purposes was of German origin. Further credit should be given to Akroyd Stuart, for cooling the vaporiser by a controlled air current; a method now popular on some small high-speed engines, and used by Krupp for their transport Diesel engines.

Mr. Charles Day said that, having been associated from the commencement with the development of the Diesel engine, he might be expected to hold a brief for Dr. Diesel's claim to priority, especially as the validity of his British patents was never challenged. The authors had shown that Akroyd Stuart's developments arose out of close personal attention to experimental work. In this he differed from Rudolf Diesel, who was a theorist and not a practical experimenter. As a professor of engineering at Munich, doubtless he explained to his students the cycle first set forth by Carnot as that which would give, in a heat engine, the highest attainable efficiency. Carnot expounded his cycle in 1824, but it received little attention until Lord Kelvin endorsed it and brought about its general acceptance in 1848-49. For a long time the Carnot cycle seemed to have no practical application, but Diesel had inspirations that appeared likely to make it practicable. Unfortunately, the power generated was insufficient to overcome the friction of the engine. Nevertheless, it attracted considerable attention and was taken up by very capable engineers. If ever it became possible to make a frictionless engine, the Carnot cycle might then be practicable, and maximum heat efficiency obtained. It would be seen that only one feature of Diesel's conception had been retained, namely, the spraying of fuel direct into the cylinder at the end of the compression stroke. Most of this elimination was the work of the practical engineers, who took up the Diesel engine and brought it from a theoretical conception to a system of operation differing only in one important point from that arrived at by Akroyd Stuart—that the fuel was sprayed into the cylinder instead of into a vaporising chamber. The first successful Diesel engine was completed in Germany in 1897. The first British-built Diesel engine was built by Mirrlees in the latter part of 1897, and the early part of 1898. An official test of it was made by Professor W. H. Watkinson in 1898.

Mr. A. H. Goldingham recalled that he was first employed by Richard Hornsby and Sons, Grantham, in 1892. The manufacture of Hornsby-Akroyd oil engines, of 1½ h.p. to 16 h.p. per cylinder, was then in full swing, several engines being completed daily. They were all of the type with unjacketed vaporiser, but with water-jacketed fuel-injection valve and with the fuel-oil pump, supplying the fuel-inlet sprayer, actuated by the same lever as the air-inlet valve. Thus, fuel injection into the vaporiser took place as the air entered the combustion space, in accordance with Patent No. 15994. He was sent to New York in 1894 by Messrs. Hornsby, the De La Vergne Company, who had bought the patent rights, having had difficulty in making the American-built engines work. The Hornsby-Akroyd engines built in New York in 1894 were duplicates of those built at Grantham, and more than 1,000 were constructed between 1894 and 1912. The first engine which he built in America had been recently placed in the Smithsonian Institute at Washington as a historical exhibit. The engine supplied to Fawn Grove, Pennsylvania, and mentioned in the paper, was not for pipe-line work. The first oil engines to be used for pipe lines were the 85-h.p. single-cylinder horizontal type, supplied to the Gulf Pipe Line Company and were installed in Texas.

Reference was made to Mr. John W. Young, and to the work he did as assistant to the chief engineer at Grantham from about 1890 onward. He had been on terms of very close friendship with Mr. Young from 1892 until Mr. Young's death in January, 1939. The success of the Hornsby-Akroyd engine was undoubtedly due, in very large measure, to his work, and he would like to see Young's efforts, and the success he achieved, more fully recognised.

Mr. R. Wailes, explaining that he was a grandson of the George Wailes who made four of Akroyd Stuart's engines, between 1889 and 1891, said that, unfortunately, all the records of the work done by the firm for Akroyd Stuart were destroyed in 1906, with the exception of some cost books, which told very little, and 17 working drawings of engine details. These drawings he had brought to the meeting for inspection, and he hoped that eventually they would be offered to some institution or museum for examination, to determine whether they were worth preservation. [Four of the drawings are reproduced in Figs. 1 to 4, on this and the opposite page.—ED., E.] It was certain that four complete engines were made by Messrs. George Wailes and Company, and the cost books showed that a number of parts were made also and sent to Bletchley. Only two people survived, who had worked with George Wailes and Company at that time, namely, the speaker's father and uncle. The latter had most to do with Akroyd Stuart, whom he recalled as "a very courteous gentleman." One of the engines was sent to France, but he could not recollect whether it was one of the Bletchley engines or one of those made in London.

(To be continued.)

THE LATE MR. SUMMERS HUNTER, C.B.E.

THE marine-engine building industry has lost one of its best-known figures by the death, which took place on January 7, of Mr. Summers Hunter, C.B.E., for many years chairman and managing director of Messrs. The North Eastern Marine Engineering Company, Limited, Wallsend-on-Tyne. Mr. Hunter, who had relinquished the position of managing director at the end of 1928, and that of chairman in the following July, was in his 84th year.

Summers Hunter was a native of Inverness, where he was born in 1856, and where he received his early schooling at the Royal Academy; but during his boyhood the family moved south to Staffordshire, and he was only fourteen years of age when the death of his father obliged him to leave school. Accordingly, he was apprenticed to the general engineering firm of Messrs. Barker and Cope, at Kidsgrove, meanwhile continuing his education in the evenings at the science classes of the Wedgwood Institute, Burslem. The work on which he was engaged with Messrs. Barker and Cope included the equipment of iron and steel works, collieries, and pumping installations—a circumstance to which may be due the fact that the North Eastern Marine Engineering Company, under his direction, undertook the construction of a number of waterworks pumping engines—and it also brought him into contact with some of the leading civil and mechanical engineers of the time, among them George Parker Bidder, the "calculating boy," who was president of the Institution of Engineers in 1859. Hunter remained with Messrs. Barker and Cope for some time after completing his apprenticeship, but in 1880 he decided to take up marine engineering and obtained a post in the Sunderland Engine Works of the North Eastern Marine Engineering Company. After a short period in the shops, he went to sea and secured a Board of Trade first-class certificate, returning to take up a staff appointment at the Wallsend works of the same company, then recently opened.

Mr. Hunter's advancement at Wallsend was rapid, and, after holding various departmental positions, in 1895 he was appointed general manager. Election to the board of directors followed four years later, and in 1900 he became managing director. At his retirement, in 1929, he had been chairman of the board for nine years. Although the firm built geared-turbine machinery for the Admiralty during the last war, and latterly, during his chairmanship, took up the construction of Werkspoor Diesel engines, the greater part of their output of machinery consisted of reciprocating steam machinery, to the development of which they contributed materially under Mr. Hunter's progressive direction, notably by his strong advocacy of superheating. On six occasions the firm's output of marine machinery was the highest in the world, on a basis of aggregate

EARLY AKROYD STUART OIL ENGINES.

(See Opposite Page.)

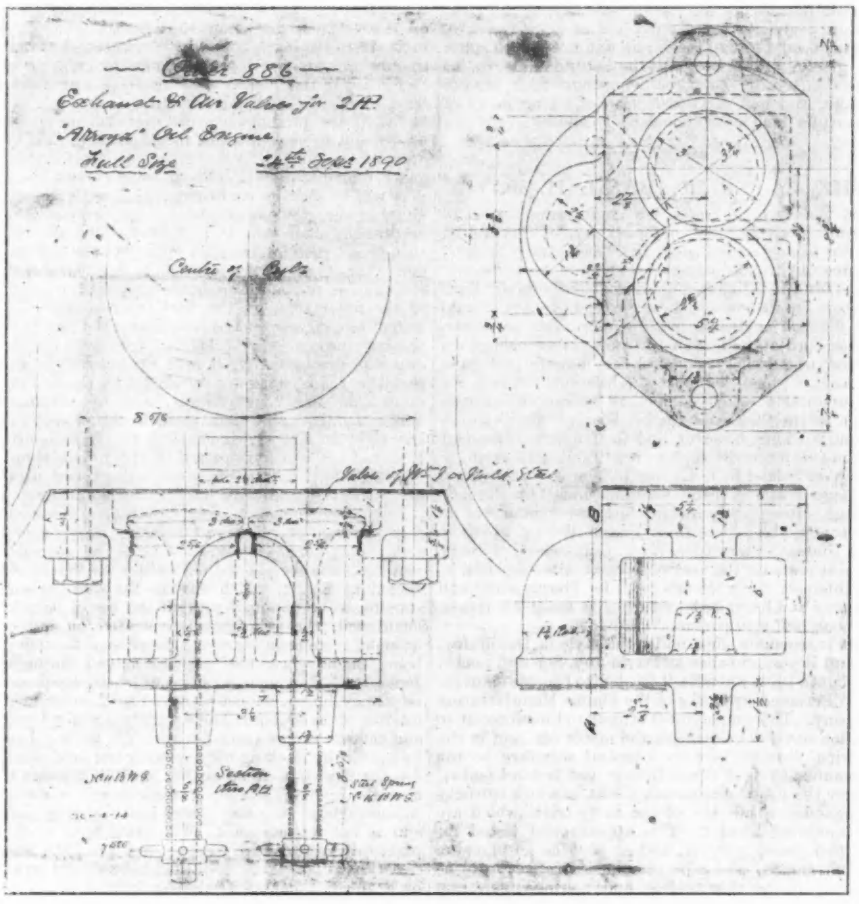

Cylinder 856
Exhaust & Air Valves for 2 H.P.
"Akroyd" Oil Engine
Full Size
24th June 1890
Centre of Cylr
Valves of Wrt Iron & Fitted S. Steel
Section thro' A B
Steel Spring
Cylinder 9 dia. x 12 Stroke
For Patent "Akroyd" Oil Engine
Scale 3 in = 1 ft
2nd Nov. 1890

FIG. 3.

FIG. 4.

indicated horse-power. He was also responsible for one of the first complete engine works electrifications, the Wallsend works being equipped throughout with electric drive to the machines, cranes, etc., in 1900, and the Sunderland works in 1901, current being obtained from the Neptune Bank power station. For some years the company was the largest consumer in the country of current from a public supply. The importance of metallurgy in marine-engine design and construction was another factor to which Mr. Hunter gave early consideration, to a degree in advance of the general practice of his time.

During the Boer War, Mr. Hunter took an active part in the Volunteer movement, and held a commission as Captain in the Northumberland Fusiliers; but in the last war his experience was, perhaps, more appropriately applied in his membership of various Government committees, including the Committee on Shipping and Shipbuilding, the Shipping Controller's Committee, the North-East Coast Armaments Committee, and the Tyne and Wear Board of Management for shell production, under the Ministry of Munitions. For these services he was made a C.B.E. in 1918. He also served on the Bulkhead Committee. In industrial affairs, he was necessarily prominent, and in questions of technical education, also, he took an active interest, serving as a member of the Council of Armstrong College (now King's College), Newcastle-on-Tyne. He was a member, of long standing, of the North-East Coast Institution of Engineers and Shipbuilders, of which he was president in 1908-1910, and in 1932 was elected an honorary Fellow. He was also a member of the Institutions of Civil Engineers and Mechanical Engineers, the Institution of Engineers and Shipbuilders in Scotland, and the Institute of Metals; an honorary vice-president of the institution of Naval Architects; and was president of the Institute of Marine Engineers in 1912-13. His encouragement of metallurgical research in connection with engineering was recognised by a vice-presidency of the British Cast Iron Research Association. At various times he held directorships in the Iron Trades Employers' Insurance Association, the Hydrogen, Oxygen and Plant Company, Limited, the Liquid Oxygen Explosives Company, Limited, and the Tyneside Tramways and Tramroads Company.

THE LATE DR. W. E. LILLY.

WE have learned with regret of the loss of a valued contributor to ENGINEERING, by the death of Dr. W. E. Lilly, M.B.E., Emeritus Lecturer in Mechanical Engineering at Trinity College, Dublin. Dr. Lilly had been living in retirement for some years at East Runton, near Cromer, where he died on January 3.

Walter Elsworthy Lilly was born in London on March 19, 1867, and received his early education at Aske's Hatcham School, Brockley, and at Lewisham High School. In 1882 he commenced an engineering apprenticeship at the Brixton Engineering Works of Messrs. Stephens and Woodman, but in March, 1884, transferred to Messrs. George Walter and Company, Phœnix Engine Works, Blackfriars, where he remained as an improver until June of the following year. He then spent a year at the Whitechapel Engine Works as fitter and turner, and a further six months in a small works in Lymington, Hampshire. In February, 1887, he returned to London, to take a post as draughtsman at the Albert Dock Engine Works, which he held until 1891, relinquishing it on winning a Whitworth Exhibition. He then left London for Dublin, on appointment as assistant to the Professor of Engineering at the University. In 1895, he was given charge of the engineering laboratory at Trinity College, together with an appointment as lecturer on steam engines and experimental mechanics. Meanwhile, he continued his own studies and, in 1898, graduated as B.A. and B.E., achieving the higher degrees of M.A. and M.E. three years later. Subsequently, the University conferred upon him the degree of D.Sc. He became Lecturer in Mechanical Engineering in 1903, retaining that position until he retired in 1924.

Although mechanical engineering was his ostensible province, Dr. Lilly's interest always showed a strong leaning towards statics, and most of his published writings, which were numerous, dealt with problems of structural theory, more especially the strength of columns. To the Institution of Mechanical Engineers, of which he became a member in 1903, he presented a paper on "The Strength of Columns," which was reprinted in the 80th volume of ENGINEERING; and others of his contributions to our columns included, in the same volume, "Shearing Stresses," and, on later occasions, "Web Stresses in Plate Girders" (1907), "The Design of Struts," and "The Strength of Solid Cylindrical Struts" (1908), "The Rankine-Gordon and Euler's Formulæ for Columns" (1909 and 1910), and, in 1938, "A Modified Theory of Elasticity," which aroused a certain amount of controversy. Certain of these studies were incorporated in a book, published in 1908, on *The Design of Plate Girders*. To the *Proceedings of the Institution of Civil Engineers* he contributed papers on "Moving Loads on Railway Underbridges" and "Eccentrically-Loaded Columns," the latter being awarded a Telford Premium in 1910; and other papers were presented or contributed by him to the transactions of the American Society of Civil Engineers, the Junior Institution of Engineers, the British Association, and the Institution of Civil Engineers (Ireland). He served the last-named institution as a member of Council for a number of years, and as president in 1917, and at the time of his death was

one of the two honorary members on its roll. He was also an honorary member of the Junior Institution of Engineers, which he had joined as an ordinary member in 1888 and of which, also, he was a member of Council for periods totalling nearly 20 years.

THE LATE MR. W. A. S. CALDER.

WE note with regret the sudden death, as the result of heart failure, of Mr. William Alexander Skeen Calder, on January 6, at his home in Anscombe-road, Worthing, Sussex. Mr. Calder, who was in his sixty-seventh year, was serving as President of the Institute of Chemistry, and had been connected all his life with the chemical industry; he was for a number of years a delegate director of Messrs. Imperial Chemical Industries (General Chemicals), Limited. He retired some two or three years ago, and took up his residence in Worthing. Mr. Calder received his scientific training at King's College, London, and at the Royal College of Science, South Kensington, and, in 1892, joined the staff of Messrs. F. C. Hills and Company, sulphuric-acid manufacturers, Deptford, London, S.E. Mr. Calder's long association with Birmingham and the Midlands began in 1899, when he was appointed chief chemist and manager of Messrs. Chance and Hunt, Limited, Oldbury, of which firm, now controlled by Messrs. Imperial Chemical Industries, Limited, he became managing director in 1917. When the works were taken over by the Ministry of Munitions during the last war, in addition to an increased production of acids and heavy chemicals, one of this country's most important installations for the manufacture of T.N.T. was developed under Mr. Calder's direction. He was also co-inventor, with Dr. C. C. Fox, of the Calder-Fox scrubber for the removal of liquid and solid particles from gases.

Mr. Calder became a member of the Institution of Chemical Engineers in 1924, and always took an active part in the administration of that organisation, serving as President in 1931. He was associated for many years with the Society of Chemical Industry, as member of the Council and as vice-president, and was elected President of the Society for the year 1935-36, taking office at the annual meeting of the Society in Glasgow in July, 1935. Mr. Calder became a Fellow of the Institute of Chemistry in 1917, was elected a member of the Council in 1935, and was inducted President in March, 1939. At the time of his death he was also a member of the Industrial-Chemistry Committee of the Ministry of Labour and National Service. He was for long a member of the executive board of the Chemical and Allied Employers' Federation, and had also served on the Chemical Standardisation Committee, the committees of the National Physical Laboratory, and others of a like nature. MR. CALDER was for many years a Fellow of the Chemical Society and had served on its Council.

THE LATE MR. R. A. SLOAN.

To the heavy list of engineering obituaries that we have had to place on record in recent weeks must be added that of one of the oldest surviving Whitworth men, Mr. Robert Alexander Sloan, whose Whitworth Scholarship was dated 1874. To professional circles beyond Merseyside, at least in later years, he was not widely known in person, although his name was more familiar in the title of the firm of consulting engineers and patent agents, Messrs. Sloan and Lloyd Barnes, which he founded in Liverpool more than half a century ago; but his influence was extensive as a lecturer in engineering subjects at the Liverpool School of Science and Technology (afterwards the Municipal Technical College) for very many years, and few of those who passed through his hands can have failed to carry away a vivid impression of his personality.

Mr. Sloan, who was in his eighty-fifth year when he died in Birkenhead, on January 5, was a former scholar of Liverpool Institute, which he left in 1871 to begin an engineering apprenticeship with Laird Brothers (now Messrs. Cammell Laird and Company, Limited). At the age of 18, he won his Whitworth Scholarship, a success which he followed with a Whitworth prize of 40*l.* in 1875, another of 50*l.* in 1876, and a third, of 60*l.*, in 1877. He completed his apprenticeship, and, a portion of the three-years' period of the scholarship being still unexpired, he was able to obtain a few months' experience in the works of Messrs. Sir Joseph Whitworth and Company at Manchester before returning to Laird Brothers to take up an appointment as draughtsman. He remained in their drawing office for six years, before leaving to join the staff of the Liverpool School of Science and Technology. In 1887, in conjunction with a former pupil, Mr. J. E. Lloyd Barnes (Wh. Sch., 1883), he began to practise as consulting engineer and patent agent, while continuing to lecture in the evenings. He retired in 1915.

Mr. Sloan became a member of the Institution of Mechanical Engineers in 1891, and of the Liverpool Engineering Society in 1894, and was also a Fellow of the Chartered Institute of Patent Agents; but his particular aptitudes were most marked, perhaps, in his lectures, which were not only models of clarity, but were notable for his careful selection of the right word in a given context. By nature a precisian in thought, deed and expression, he was not one to suffer fools gladly, or at all; but he set no limit to his personal attention to those who took their studies seriously, and had the satisfaction of seeing many of them attain high professional responsibility.

THE LATE MR. BASIL H. JOY.

FOR variety of interests, few engineering careers of the Nineteenth Century surpassed that of David Joy, inventor of Joy's valve gear, the "assistant cylinder," the first hydraulic organ-blower, and many other devices, and it is not surprising that his son, Mr. Basil Humbert Joy, whose death we regret to record, should have touched engineering life at a number of points. He was born at Redcar in 1870, his father being then engaged in Middlesbrough in the manufacture of a new form of steam hammer which he had devised, for the production of which he had started a business known as the Cleveland Engine Works. This venture did not last long, however, and the family was resident in London when Basil Joy began his education at Aldenham School in 1882. In 1888 he left school and commenced a five-years' training under his father's tutelage, subsequently seeking further experience as an improver in the Albert Dock Engine Works, where he was a contemporary of Dr. W. E. Lilly, whose obituary notice appears on the previous page. After a period as draughtsman with Messrs. J. I. Thornycroft and Company at Chiswick, he returned to assist his father, who took him into partnership in 1896.

The partnership, first under the style of David Joy, Son and Pryor, and then as David Joy, Son and Smith, lasted until 1901, when Basil Joy left to become manager at the Bermondsey works of the Simms Manufacturing Company. This employment stimulated his interest in the then novel development, the motor car, and in the following year he became technical secretary to the Automobile Club of Great Britain and Ireland (subsequently the Royal Automobile Club), in which capacity he organised a number of the early trials which are now motoring history. This appointment lasted for only two years, however, and in 1905 he left London for Dartmouth, where he remained for five years as manager of the shipbuilding and marine-engineering establishment of Messrs. Simpson, Strickland and Company, Limited. The climate of Devon proving unsuitable to his health, he resigned this position in 1910, and shortly afterwards was appointed secretary of the Institution of Automobile Engineers, then a small society with a membership of only 300. At first, the appointment carried with it permission to undertake consulting work, but the expansion of the membership, which rose to some 2,500 during Joy's secretaryship, eventually precluded any such extraneous activities, and the duties of the position represented his full-time employment for a number of years prior to his retirement in 1934. He died at Burnham-on-Crouch, Essex, on January 6. Although latterly the work of the Institution of Automobile Engineers fully occupied his time in earlier days he had taken an active part in the work of other institutions and societies, becoming a member of the Institution of Mechanical Engineers in 1913, and serving as chairman of the Junior Institution of Engineers from 1898 to 1900, and as president of the Society of Model and Experimental Engineers from 1920 to 1922.

THE BRUSH-KOELA GAS PRODUCER.

SOME eight months ago,* we gave a description of the Koela gas-producer for road vehicles, manufactured by Messrs. Koela Producer-Gas Plant Company, Limited. As mentioned in our columns, the manufacture of this producer has since been taken over by Messrs. Brush Electrical Engineering Company, Limited, of Loughborough, Leicestershire. Certain modifications have been made to the original design, and the producer is now known as the Brush-Koela Duo-Draught model. It is shown in its latest form in Figs. 1 to 4, opposite. As stated in our previous article, the original producer was designed to operate on the up-draught system, and the principle alteration lies in the addition of a second air inlet enabling a cross draught to be employed when required.

The makers claim that the up-draught system results in the greatest economy, the passing of the pre-heated air upwards through the grate giving slow and evenly-distributed combustion. Where mineral-derived fuels are used, temperatures can be controlled below the fusion point of the ash by the addition of superheated steam. In addition, the air velocity through the fire bed is said to be much lower, with a reduction in resistance, when the up-draught system is employed. On the other hand, producers operating on this system are somewhat slow in starting, and in their response to a sudden increased demand for gas, as compared with those employing cross draught, and it is for this reason that the second air inlet has been added to the original design. As a result of this addition, the producer can be operated as either an up-draught or cross-draught model at will; the cross-draught is intended to be employed only for starting or when an exceptional demand for gas arises.

It will be seen by comparing Fig. 2 with the section given in our previous article that the arrangement for up-draught operation is unaltered. The description then given, therefore, applies equally to the new model, and a brief recapitulation will suffice. Water from the tank *a* passes through the drip-feed regulator *b* to the inner tube of the heat interchanger *c*. The water supply is vaporised in this tube by the gas passing through the jacket. As regards the cross-draught arrangements, it will be noticed in Fig. 2 that there is a change-over valve *d* on the top of the inner tube of the exchanger, and by turning this valve, the air supply is diverted to the pipe shown to the right in Fig. 3, and below the interchanger in Fig. 4, from which it passes to the nozzle shown in Fig. 3 projecting into the grate. The outlet arrangements are the same with both methods of operation.

Engines fitted with this producer are normally started up on petrol, the change over to gas operation then being made in 60 seconds to 90 seconds. If required, however, a hand fan can be fitted, shown dotted in Fig. 2, which enables the draught air for starting to be obtained without the use of petrol. As mentioned, the generator is operated on the cross-draught system on starting, the change to updraught being made when the fire has spread through the generator. The generator is of sheet steel, and a refractory lining, shown at *e* in Fig. 2, surrounds the interior of the firebox. The firegrate is easily removed, and there is ample space for ash. The firebox door can be opened by slacking off one wing nut, and when the door is closed, a clamping bar applies pressure to an air-tight joint. The cross-draught nozzle is made of a silicon-carbon compound of high heat-resisting qualities, and is not water cooled. The grate is of steel with practically vertical fire bars, as shown in Figs. 2 and 3.

A typical arrangement of the producer and scrubbers on a Morris Commercial tipping lorry is illustrated in Fig. 1. In this case, the scrubbers are mounted on the cab roof, but when a tipping body is not fitted, they may be conveniently mounted below the body at the rear. At the moment only one size of producer, known as the No. 2 model, is in production. This producer, which is mainly suitable for the 50-cwt. unladen class of vehicle, is 4 ft. 5 in. high by 14 in. diameter, and the scrubbers are each 2 ft. 6 in. long by the same diameter. The complete plant weighs from 2½ cwt. to 3 cwt., according to the lay-out adopted. The capacity is from 40 lb. to 70 lb. of fuel according to the type used, and the consumption is approximately 1 lb. per mile.

* See ENGINEERING, vol. 147, page 631 (1939).

HERBERT AKROYD STUART AND THE HEAVY-OIL ENGINE.*

By T. HORNBUCKLE, B.Sc., A.M.Inst.C.E., and A. K. BRUCE, M.I.Mech.E.

HERBERT AKROYD STUART was born at Halifax Yorkshire, on January 28, 1864. He was the son of Charles Stuart, who came from the neighbourhood of Paisley. Charles Stuart, a man of marked inventive ability, possessed of private means, occupied himself in engineering work of an experimental kind. He ultimately settled in Bletchley, Buckinghamshire, where he had a small factory known as Bletchley Iron and Tin Plate Works. Of Herbert Akroyd Stuart's early education, all that is known is that he was at St. Bartholomew's Grammar School, Newbury. The school records contain no details of him beyond a bare reference to the name "H. A. Stuart" in the school register for 1876. Particulars of his technical education are equally vague, but it is certain that he acted, for an unspecified period, as a junior assistant in the Mechanical Engineering Department at the City and Guilds of London Technical College, Finsbury, London. No mention of his name could be found in the records, but statements of the late Professor William Robinson and the late Professor Silvanus P. Thompson are authoritative as to his connection with Finsbury. On leaving Finsbury Technical College, Akroyd Stuart joined his father at Bletchley Iron and Tin Plate Works,

* Paper read before the Diesel Engine Users Association in London, on Thursday, January 11, 1940. Abridged.

THE BRUSH-KOELA GAS PRODUCER.

(*For Description, see Opposite Page*).

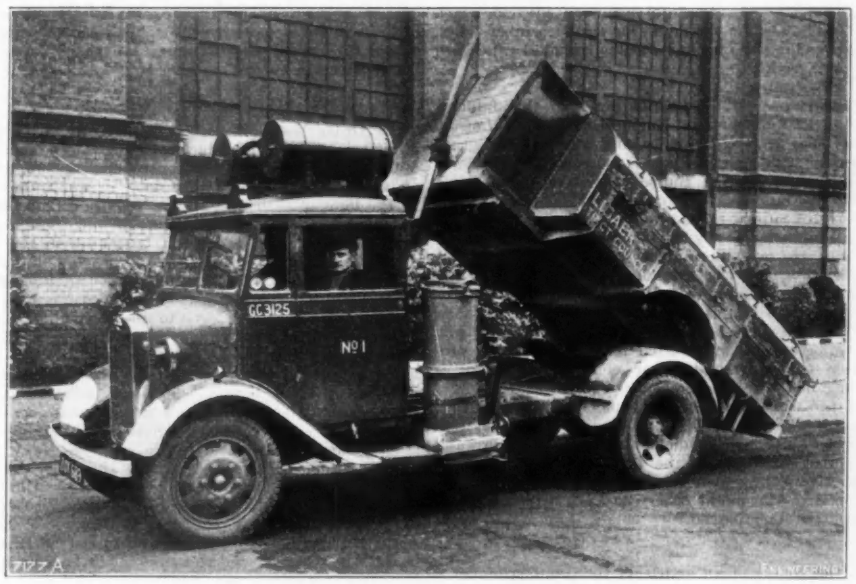


FIG. 1. PRODUCER PLANT ON MORRIS COMMERCIAL LORRY.

Fig. 2.

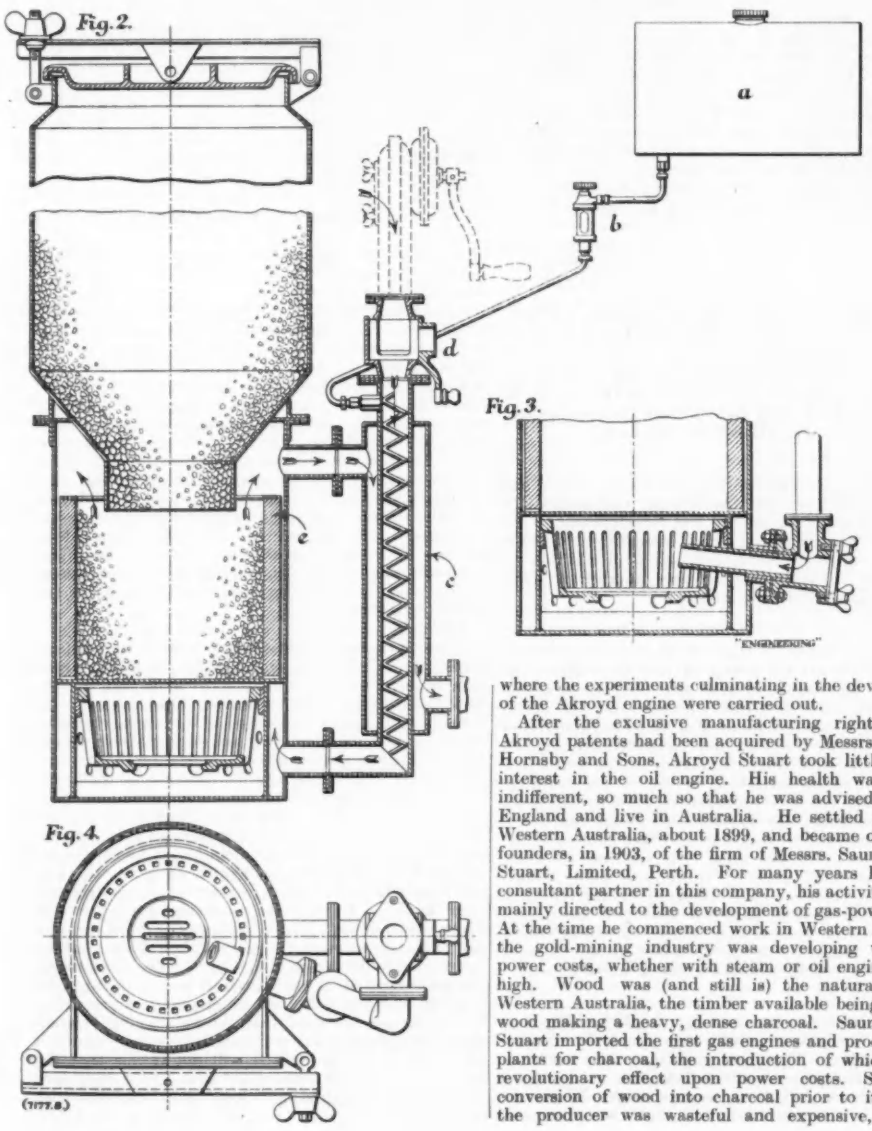


Fig. 3.

Fig. 4.

where the experiments culminating in the development of the Akroyd engine were carried out.

After the exclusive manufacturing rights in the Akroyd patents had been acquired by Messrs. Richard Hornsby and Sons, Akroyd Stuart took little further interest in the oil engine. His health was always indifferent, so much so that he was advised to leave England and live in Australia. He settled at Perth, Western Australia, about 1899, and became one of the founders, in 1903, of the firm of Messrs. Saunders and Stuart, Limited, Perth. For many years he was a consultant partner in this company, his activities being mainly directed to the development of gas-power plant. At the time he commenced work in Western Australia the gold-mining industry was developing well, but power costs, whether with steam or oil engines, were high. Wood was (and still is) the natural fuel in Western Australia, the timber available being a hard-wood making a heavy, dense charcoal. Saunders and Stuart imported the first gas engines and producer-gas plants for charcoal, the introduction of which had a revolutionary effect upon power costs. Since the conversion of wood into charcoal prior to its use in the producer was wasteful and expensive, Akroyd Stuart investigated the possibility of putting the wood directly into the producer. The outcome of this investigation was the Akroyd down-draught wood gas producer. With this plant, the consumption of dry wood (mulga) was approximately 2 lb. per brake horse-power-hour, against approximately 1 lb. of charcoal per brake horse-power-hour. Since the conversion to charcoal called for approximately 5 lb. of raw wood per lb. of charcoal, the resulting net economy was very large.

Akroyd Stuart, who never married, died at Claremont, Western Australia, on February 19, 1927. He left directions that, after his death, all his papers, drawings and models were to be destroyed. A further instruction was that his body should be brought to England and interred in his mother's grave in the burial ground of All Souls' Church, Halifax. "Akroyd" was the maiden name of the inventor's mother, to whom he was deeply attached. It is believed that this was the reason why the name "Akroyd" was given to the engine.

In the account which he wrote of "Heavy-Oil Engines of Akroyd Type," the late Professor Robinson related that Akroyd-Stuart was guided to the investigation of oil engines by an accident which happened to him at Llanelly. This was in 1885, the occasion being the accidental spilling of oil from a paraffin lamp. The oil fell into a tinning pot and, being vaporised by contact with the molten metal, produced a mild explosion when ignited by the lamp. Akroyd Stuart escaped serious injury but, impressed by what he had seen, reproduced the explosion by dropping more paraffin on to the molten tin. Thus satisfying himself that there was no mystery about what took place when a mixture of oil vapour and air is ignited at atmospheric pressure, he proceeded to the study of internal-combustion engines, which was to prove of historic importance. It was Mr. Charles Stuart who commenced the experiments, at Bletchley, with internal-combustion engines. He did not persist in them, nor did he afford any encouragement to his son to go on with the work. Mr. W. J. Holloway (who was employed in the works at the time) has recorded that, when Mr. Charles Stuart abandoned the investigations on petrol engines, he remarked to his son Herbert (and to Mr. Holloway) that they "would never make an engine."

Akroyd Stuart's first patent (No. 9866) was taken out in 1886, the inventor being then in his twenty-second year, but it was not until May 8, 1890, that he (with Charles Richard Binney) applied for patent No. 7146 relating to "Improvements in Engines Operated by the Explosion of Mixtures of Combustible Vapour or Gas and Air." The experiments leading up to patent No. 7146 of 1890, and subsequent applications for patents, were made at Bletchley on a petrol engine, a type of prime mover which, in those days, was very much of a novelty and regarded as more or less dangerous. It appears to have been the element of hazard due to the use of petrol that impelled Akroyd Stuart and those assisting him to change over to paraffin. Mr. W. J. Holloway states that the procedure consisted in starting up on petrol and changing over to paraffin when the engine had been well heated. The ignition equipment consisted of Leclanché cells and sparking plug. It was noted that the engine continued to run on paraffin so long as the load remained steady and certain parts of the engine remained hot.

Mr. Holloway's description of the successive developments is as follows: "We continued to expose more surface of the combustion chamber to the heat of the combustion. That seemed to be moving in the right direction. We continued in that direction until the combustion chamber was almost void of water jacket. Now we had an engine that would run under certain conditions but not satisfactorily. At this stage we began to blame the electric ignition. We had no magneto and sparking plug like those used to-day. All we had was Leclanché cells and sparking plug made by ourselves. We now dispensed with electric ignition and heated the combustion chamber externally with a lamp. When the combustion chamber was hot enough, we could start the engine without petrol by pumping the paraffin direct into the combustion chamber. At this stage we took a little refreshment because excitement was running high. Our troubles had not ended, since when there was sufficient heat maintained to keep the engine running on light loads, we soon got pre-ignitions when working on full load, hence came the timing of injection of oil on or near the end of the compression stroke. The news soon floated about and we had some fuel offered to us. It was a by-product from some distillery, I can't remember where, but we used it and the engine ran on it quite as well as it ran on paraffin. In fact we made it our standard fuel and we named it 'A V O' (Akroyd Vapourising Oil)." These words of Mr. Holloway (written on April 24, 1939, from his personal recollection of the actual experiments) describe the circumstances in which Akroyd Stuart and those working with him arrived at automatic ignition with timed injection of fuel oil.

(*To be continued.*)

LABOUR NOTES.

AT conferences in London, last week, the engineering trade unions submitted, for the consideration of the Engineering and Allied Employers' National Federation, the arguments which they have prepared in support of their applications for a wage increase of 10*s.* a week. At the first of the two meetings, Mr. Tanner, the president of the Amalgamated Engineering Union, stated the case of his own organisation and also that of the National Union of Foundry Workers, and later in the day, Mr. Hodgson, the general secretary of the Boilermakers' and Iron and Steel Shipbuilders' Society, spoke in support of the case of the Engineering Joint Trades Movement, of which neither the A.E.U. nor the Foundry Workers is a unit. Sir Alexander Ramsay, Director of the Engineering and Allied Employers' National Federation, replying at both meetings, said that the arguments submitted, which were based on the condition of the industry and the cost of living, would be carefully considered by the employers and their decision be communicated to the unions at a later conference. Judging from a statement by Sir Alexander Ramsay, which was issued to the unions, the employers, in their consideration of the matter, are not to have regard to those facts alone. Sir Alexander suggested that there were grave general reasons why the engineering industry should try to discover a policy to safeguard it from the dangers of inflation.

It was the business of trade unions, Sir Alexander Ramsay admitted, to try to increase the spending power of their members, but they must be sure that the course they were pursuing would achieve the end they had in mind. Rising costs meant rising prices, and if wages went up prices must follow. If domestic prices went up the consumers must pay them; if export prices went up our imported foodstuffs and raw materials would cost more, or, if the foreign customers did not buy at the higher price, our situation would deteriorate still further. When costs went up there was an almost inevitable reaction on the external value of the pound which affected our purchasing power. In the period 1914-18 the cost of living went up, wages followed, and the process was repeated until we got into the vicious spiral, which had serious results on the national finance and on industry. None was likely to forget the post-war decade, with its loss of employment, loss of earnings, loss of exports—a disastrous sequence of events which might have been mitigated if the position had been understood then as well as it was now.

Sir Alexander concluded by putting it to the unions that—whatever the decision on this application for an increase of wages—those who were charged with the conduct of the industry would be failing in their duty if they did not give consideration to these matters. "Rather (he said) our interests lie along the line of seeking to discover together, if possible, a policy which will protect us from the kind of danger I have indicated."

In the course of his speech at the Mansion House, London, last week, the Prime Minister said that he did not mean to imply that there must be no increase of wages, but he did say that it would be a mistake to tie up wages to the cost of living. In the end that could benefit no one, because it could only give a violent impetus to the vicious spiral of alternately rising prices and wages and that was a thing that all of us wanted to avoid.

Writing in his organisation's *Journal*, Mr. Charles Dukes, the general secretary of the National Union of General and Municipal Workers, says that it is wrong to tie wage rates to a cost of living index. Wage standards, he continues, are not, as yet, so accurately adjusted that automatic adjustment by a cost of living index is all that remains to be done. If the country is to meet a period of fluctuating prices and values it would be more desirable, in his opinion, to use the normal method of negotiation to effect alterations. That would be true, he claims, even if the cost of living index were accurate, but war-time control and rationing would tend, he holds, to make even the best index misleading. The sound line to take would be, he says, to continue in war as in peace "to press Labour's rightful claim to share in the prosperity of industry."

In December, the home branch membership of the Amalgamated Engineering Union decreased from 376,499 to 376,401, and the colonial branch membership from 36,753 to 36,693. The number of members in receipt of sick benefit increased from 3,754 to 3,802, and the number in receipt of superannuation benefit decreased from 14,068 to 14,065. The number on donation benefit decreased from 714 to 713, and the total number of unemployed members increased from 3,589 to 3,723.

The Ministry of Labour and National Service estimates that, at December 11, there were 41,063 fewer unemployed workers than at the date of the November return. That brings the total down to 1,361,525, which is 469,847 less than the figure for mid-December, 1938. There was little change in the industries most concerned with war production.

The writer of the editorial notes in the January issue of the Amalgamated Engineering Union's *Journal* claims that it is difficult to find any evidence that industrial activity as a whole is increasing. "The war trades proper are, of course," he says, "extending under the influence of Government contracts. The Ministry of Supply takes pride in the facts that he has placed orders for nearly 200,000,000*l.*, that 13 ordnance factories are now in production, and 16 more under construction, and that the output of ammunition has doubled since September. What the aircraft factories and the naval shipyards are doing is probably on a still greater scale. Nevertheless, it is obvious that war orders have not compensated for the decline in production generally under war conditions. There is nothing in the figures, in fact, to prove that employment as a whole has increased, but rather the contrary. The presumption that 28,000 more workpeople were absorbed into employment between October and November is offset by the fact that a considerable number of young men were called to the Colours in that period who might otherwise have helped to swell the total of unemployed."

In the course of an article in the January issue of the *Transport and General Workers' Record*, Mr. Ernest Bevin says:—"In my view, this war is likely to be a long one and there has to be a far greater consideration, scientifically, and in every possible way, if the great productive capacity of the country is to be carried on in order to maintain the forces and our export trade. The constant lecturing to the workpeople must stop. The response to the calls of the State have been magnificent. Who can deny this? It has been acknowledged in the case of seamen, fishermen and others, who are facing great risks in the service of the community. But it is not sufficiently recognised respecting those in general industry. Few people appreciate what the conditions have been like since war broke out. The difficulties of the transport men on the road and railways, the working in artificial light and under bad ventilation in factories, people going week in and week out and not seeing daylight owing to the necessity of black-outs, the cutting off of forms of leisure and entertainment, the breaking up of families and the social life of the people. All have involved a tremendous strain, and when I have to deal with these problems across the table there seems to me to be a lack of understanding and appreciation of what it all means. And yet lots of things can be done to ease the burden and to make the risks undertaken more tolerable. Words are not enough."

A shortage of skilled workers for defence needs has been reported by the Australian Commonwealth Assistant Minister for Supply and Development. The position is expected to become increasingly difficult within the next twelve months, and, in addition to skilled men, a considerably greater number of semi-skilled workers will be required.

Dr. Ley, Leader of the German Labour Front, recently explained the policy of that organisation in respect of the boys and girls who will leave school next Easter. He said that measures for the social welfare and vocational training of the rising generation must be carried on to-day more actively even than in the past. A basis had to be found for the vocational training in a satisfactory choice of careers. No training, however good, could ever compensate for a wrong choice of career, and mistakes of that kind would necessitate much expenditure by the Party, the State, and industry on measures to correct them. At the present time, it was, above all, necessary to train as many skilled workers as possible. The struggle of the German Labour Front against unskilled work was more than ever justified in time of war. There was no intention to increase the army of the unskilled by shortsighted measures for placing school-leavers in employment.

No one, Dr. Ley went on to say, would be obliged to choose an occupation in which he could not develop his capabilities. That was important, because compulsion would prevent any satisfaction in the work done. Children and their parents might be certain that from a vocational point of view the future was more assured than ever before. The best prospects naturally existed in occupations necessary for military purposes, and for satisfying the needs of the people, such as agriculture, mining, iron and metal industries, and building, and, with regard to girls, in social, educational and welfare occupations. The Minister of Labour had, by an Order, repealed the provision, hitherto in force, under which attendance at a vocational school for young persons under 16 years of age was not included in normal working hours.

An Order has been issued jointly by the French Ministers of Labour, Education, the Navy, Air and Munitions, for the establishment of liaison committees on vocational training for workers in war industries. In the light of earlier legislative provisions concerning the employment of labour in time of war, these liaison committees, one of which will be set up in the area of each divisional labour inspector, are intended, within the framework of the general instructions issued by the Ministries concerned, to promote the activities and co-ordinate the efforts of public bodies, public or private institutions, employers' and workers' organisations and industrial undertakings, with a view to hastening on the vocational training of workers for war industries. Each liaison committee will consist of the divisional labour inspector as chairman, and one representative each of the Ministries of Education (Department of Technical Education), the Navy, Air, and Munitions. The enforcement of the Order is in the hands of the Director-General of Labour, the Director-General of Technical Education, the Director-General of Naval Shipbuilding, the Central Director of Naval Artillery, the General Technical and Industrial Director in the Air Ministry, and the Director of Labour in the Ministry of Munitions.

In May last year, Royal assent was given to a Bill amending Section 502 of the Criminal Code of Canada, and providing for the imposition of a fine or imprisonment, or both penalties, against the employer who refuses to hire or dismisses a workman solely on the ground of the latter's membership of a lawful trade union or association. The new provisions are of nation-wide application, for while labour legislation is to a large extent within the competence of the Provincial legislatures, criminal law comes within the legislative powers of the Federal Parliament.

The amendment actually makes the employer or his agent liable to a fine not to exceed 100 dols. or to three months' imprisonment in the case of an individual, and to a fine not to exceed 1,000 dols. in the case of a company or corporation, for refusing to employ or for dismissing any person on the ground that such person is a member of a trade union or association or combination of workmen or employees legally formed for the purpose of advancing in a lawful manner their interests, and organised for their protection in the regulation of wages and conditions of work. The same penalties may be imposed against the employer or his agent who seeks by intimidation, threat of loss of position or employment, or by causing actual loss of position or employment, or by threatening or imposing any pecuniary penalty, to compel workmen or employees to abstain from belonging to the trade union, association or combination to which they have a right to belong. The conduct of the employer or of his representative is equally punishable where he merely agrees or conspires with another employer to do any of the acts specified above.

A union having a closed-shop agreement with an employer may not be compelled to admit non-union men to membership, according to a decision of the New York Supreme Court for New York County. In this case, there was a closed-shop agreement between the union and the employer, but during a rush season when sufficient union men were not available, non-union men were employed. However, additional members were admitted to the union, and as a consequence the non-union men were deprived of their privilege to work under the provisions of the closed-shop agreement. They thereupon brought suit alleging an unlawful conspiracy to deprive them of the right and opportunity to engage in their calling as brewery-lorry drivers. In its decision dismissing the suit, the Court declared that "the fundamental legal right of the plaintiffs to engage freely in their lawful calling is necessarily limited in scope by the decisions recognising the right of labour organisations to 'unionise' for a lawful end where the means employed are lawful." It was further observed that the validity of "closed-shop" agreements is now well established, and "it must follow that the Court will not decree that the union shall permit non-union men to be employed where there is an existing 'closed-shop' contract with the employers."

OIL CIRCUIT BREAKER FOR RURAL TRANSMISSION LINES.

CONSTRUCTED BY MESSRS. METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, MANCHESTER.

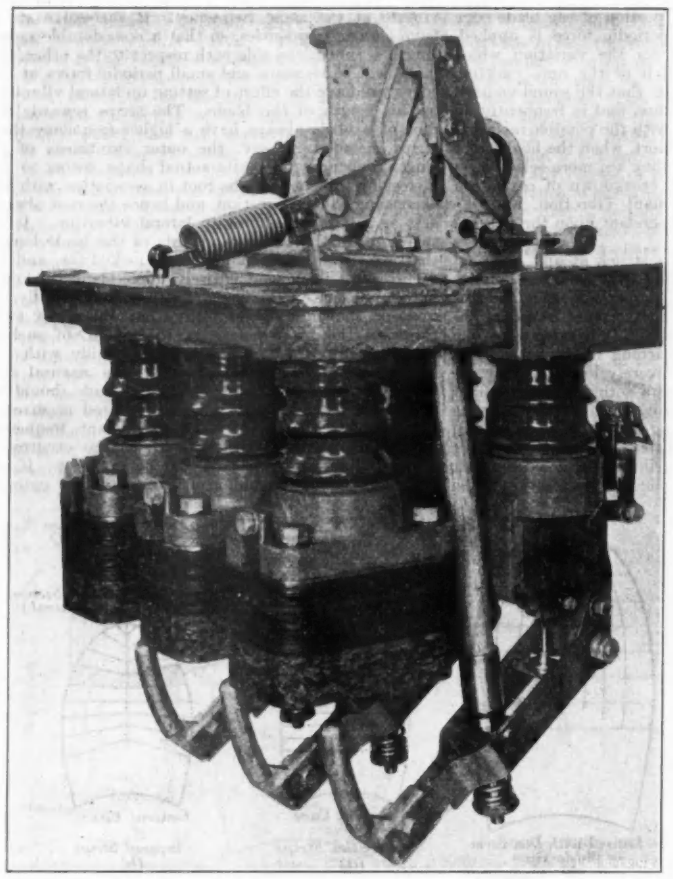


FIG. 1. CIRCUIT BREAKER AND MECHANISM ON SUB-FRAME.

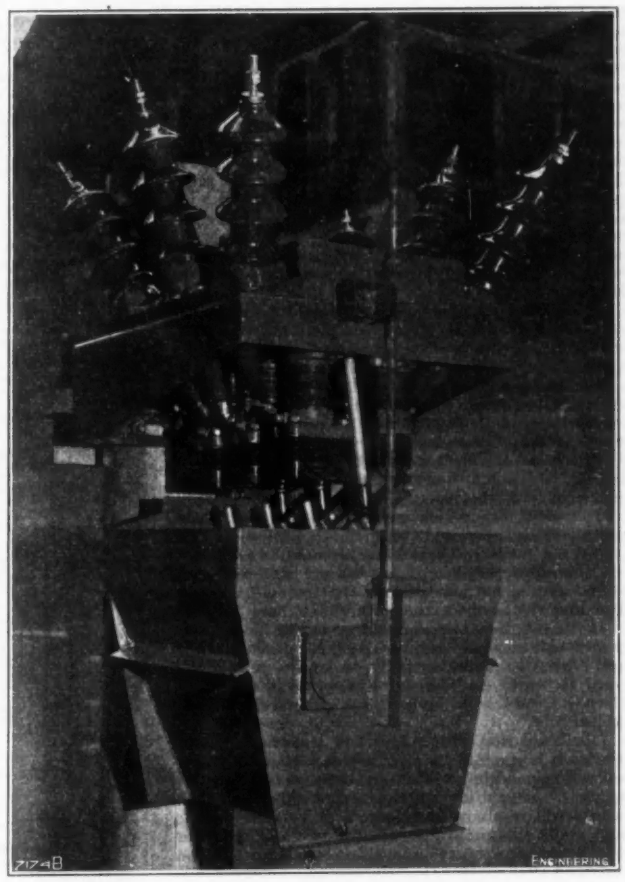


FIG. 2. POLE UNIT WITH TANK LOWERED.

OIL CIRCUIT BREAKER FOR RURAL SYSTEMS.

IN designing a circuit breaker for use on rural systems, attention must be paid, *inter alia*, to such factors as dielectric and mechanical reliability, short-circuit capacity, maintenance and convenience in upkeep. All these factors must also be considered in the light of the peculiarities of the service itself. For instance, the insulation suitable for normal 6·6-kV and 11-kV circuit breakers is not sufficient for equipment intended for installation in rural areas, since the comparatively low oil volume and the probability that maintenance will be infrequent results in a greater deterioration of the oil than would ordinarily be the case. It is also important that the dielectric strength should not be critically affected by small differences in the oil level. To ensure mechanical reliability, moreover, it is essential that the alignment or adjustment of the mechanism, especially on auto-reclose types of gear, is not affected by rough handling during transport or erection. Means should also be provided to limit the shock which can be transmitted to the delay gear when reclosing.

A further point for consideration is that a balance has to be struck between the space required for the series trip coils, the maximum short-circuit current permissible for the section of wire used, and the minimum trip value obtainable from the coil. The fact that reclosing breakers may have to operate several times on short-circuit without attention may impair the insulation strength owing to carbon having time to settle on the insulation. It is, therefore, important to reduce the quantity of carbon liberated during short-circuit and to localise its deteriorating effect as much as possible. The maintenance of rural circuit breakers has often to be carried out in inaccessible situations and in unfavourable weather. It is, therefore, essential to make this work as easy as possible.

While most engineering designs must necessarily be a compromise between their functions and their cost, in the new rural circuit-breaker which is now being manufactured by Messrs. The Metropolitan Vickers Electrical Company, Limited, Trafford Park, Manchester, 17, an attempt has been made to provide all the features indicated above as being desirable in circuit breakers for use on rural circuits in a unit of normal size and reasonable price. This equipment, the various features of which will be gathered from the illustration reproduced in Fig. 1, comprises a sheet-steel frame, with hanger irons and a detachable lid, from which the tank is hung by two lowering and raising screws. These screws also serve to secure the tank in the service position. As will be seen from Fig. 2, which illustrates a pole-mounted unit with the tank lowered, the frame has a sloping shelf on each side to which either a unit comprising three single-piece through porcelain bushings or a three-phase cable box may be bolted. These units are readily interchangeable. Bolted to this frame on a three-point mounting is a malleable sub-frame on which, as shown in Fig. 1, the complete circuit-breaker mechanism and contact assemblies are mounted. Any distortion of the outer housing cannot, therefore, affect the alignment of the breaker or mechanism parts. The sub-frame carries six porcelain posts, on three of which are mounted cross-jet pots. The other three carry trip-coil frames and hinge points to which the spring-loaded moving-contact assemblies are pivoted. As will be gathered from the illustrations, the best use is thus made of the space available and the advantages associated with single-break cross-jet operations, such as quick interruption, short total air length, minimum carbonisation and confinement of the arc to the cross-pots, which have hitherto been peculiar to large power-station circuit breakers are now obtainable on this smaller equipment.

We understand that, when tested in accordance with the provisions of British Standard Specification No. 116 of 1937, this type of circuit breaker gives an exceptionally fast interrupting performance, the total break time from the initiation of the short-circuit to interruption not exceeding 3 cycles on an 11-kV circuit, with ratings from 10 per cent. to 100 per cent. The duration of the arc was half this time. At lower currents the opening time is increased to about 5 seconds at 130 per cent. normal setting, owing to the suction discs which are incorporated to prevent tripping on momentary overloads. The advantages of this high-speed tripping at larger currents, it is claimed, are a reduction in system disturbances, contact wear, oil deterioration and, in the case of overhead lines, in damage to the wires and insulators. In addition, breakers of this speed will clear faults before most classes of relays on the breakers in the substations on the system will have had time to operate, even when these are of the so-called instantaneous type without delayed settings.

Easy access is possible to the contact and mechanism assemblies by lowering the tank and lid so that adjustments and inspection can be readily made. A new feature is the fixed-contact mounting. This enables the contact to be withdrawn from the side of the cross-jet pot after only one bolt has been undone and without it being necessary to dismantle the jet assembly. The moving contact is located by accurate grooves, thus ensuring exact alignment. The minimum adjustment is therefore necessary when changing the contacts. Moreover, the arrangement of the mechanism and trip gear adopted, it is claimed, ensures that the creepage lengths of the lift and trip rods, which pass through the centres of the series-trip porcelain supports, are the maximum, while all creepages and puncture distances are such that a complete circuit breaker has withstood a 50-cycle test of 50 kV for one minute. The impulse level is over 140 kV with 1/50 positive waves, the flashover occurring externally. This is an unusually high insulation level for a circuit breaker of normal size requiring only 11¼ gallons of oil. The auto-reclose and hand-close mechanisms are interchangeable on the same sub-frame and hand-close units may easily be converted to auto-reclose by adding and changing a few parts requiring assembly work only. The weight operated auto-reclose mechanism is cushioned by built-in compression springs, thus limiting the shock which can be transmitted to the delay gearing and mechanism. The complete breaker on its sub-frame can be removed by undoing the internal connection to the bushings and also the three-point securing bolts. A number of accessories and modified fittings, such as an auxiliary switch, shunt trips, definite minimum time delay trips, earth leakage trips and transformer mounting housings, are available.

CHARACTERISTICS OF SILENT PROPELLERS.*

By A. W. DAVIS, B.Sc.

FOR some years the problem of marine propeller-blade vibration, with the accompanying production of an audible, irritating note, has presented itself in one form or another in widely varying circumstances. In some instances, the disturbance has been of sufficient magnitude and persistence to be a source of annoyance to passengers and crew, although in many cases it would seem that the prominence recently given to the subject has had the effect of emphasising its occurrence where formerly it would have passed almost unnoticed. The effect of such sharp observation is to induce the opinion that the trouble is becoming more widespread, and a solution of the problem becomes increasingly desirable. Furthermore, in time of war it is important that a vessel should not betray its approach to enemy craft on account of propeller noise of such a penetrating character.

In their valuable paper† on the subject, Drs. Shannon and Arnold showed the results of their investigation into the obscure facts relating to the disturbing forces of vibration. They showed that, if the leading edge of a blade had a blunt profile, local cavitation would be set up by its passage through the water, and that the breakdown of the bubbles caused thereby provided the periodic forces at the blade edge which created a state of vibration in the blade itself. They also showed that they had effected cures of "singing" by sharpening the leading edge of the blade, thus eliminating the local cavitation—a term which must not be confused with cavitation as associated with the breakdown of a propeller in water. There have been instances, however, in which this sharpening has not met with the desired result, but, in view of the frequent success attending the method, the natural inference is two-fold: firstly, that the sharpening of the blade edge greatly reduces, but does not entirely eliminate, the local cavitation; and, secondly, that there is an additional factor to consider in respect of the degree to which a blade will resonate the vibrational forces applied to it.

A bell will ring with a true and penetrating note, because it is carefully cast so that each element of the bell will respond in vibration to the same frequency of impulses. A slight imperfection in the uniformity of the casting will result in an impure and less penetrating note, and if this analogy is extended to a bell in a state of ridiculous imperfection, no resonant note will be sustained after striking, and the resulting noise emitted will be due only to the forced vibration set up at the point of impact. Again, in a good resonant body, the actual force required to produce vibration is very small when it is maintained for any length of time; this is exemplified by the audible effect produced by gently passing a slightly damped finger round the rim of a tumbler.

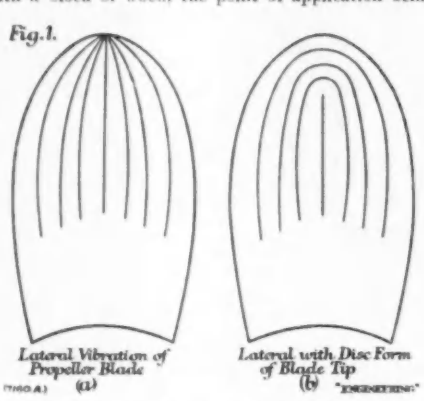
Following upon these analogies it will be convenient to refer to propeller blades as being non-resonant, resonant or semi-resonant. In the first case, if a blade is non-resonant, it will not respond to the forces set up by the periodic breakdown of local cavitation bubbles, however severe these may be; by analysis it can be shown that this type is exemplified by many non-singing blunt-edged propellers. Secondly, if a blade is resonant, it will have a certain fundamental natural frequency; it will respond in vibration to the periodic breakdown of cavitation bubbles of that frequency, and will consequently emit the corresponding note. In a state of extremely good resonance the blade will respond to the smallest periodic forces, as is instanced by the singing of a propeller with sharp leading edges. It must be recognised that the frequency of breakdown of cavitational bubbles depends upon the instantaneous speed with which the blade is passing through the water, upon the blade profile, the slip angle, the head of water, and other small factors, and consequently there is an indeterminable variation in bubble frequency along the length of the blade edge which further varies during each revolution of the propeller. It may be inferred from the limited range of notes emitted by propellers that the bubble frequency may vary from, say, 150 vibrations to 300 vibrations per second. A resonant propeller is liable to emit noise over a wide range of speed, because it is very probable that vibrational forces corresponding to the blade's natural frequency will be produced at some section along the blade edge—possibly a very short section—and the forces will, therefore, be small but the blade will pick out and resonate these small forces at the natural frequency.

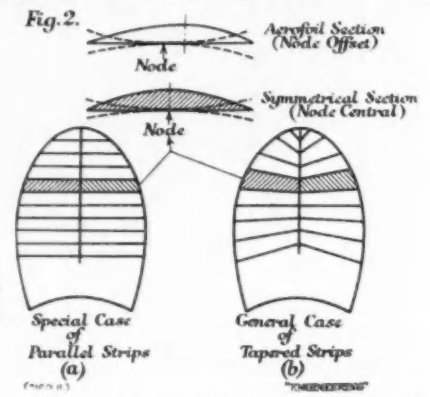
In the third case, if a blade is semi-resonant, it will possess a natural period which is not well defined. On the whole, it will be less ready to resonate to applied periodic forces, and it is likely that resonance will only occur when periodic forces of the appropriate natural frequency are applied at a suitable part of the blade edge. Propeller noise, therefore, will be conditional upon speed. The natural frequency is susceptible to variation appropriate to the portion of the blade edge at which the sympathetic periodic force is applied, and this fact may account for the variation which sometimes occurs in the pitch of the note emitted. It is also partly for this reason that the sound emitted can rarely be described as pure, and is frequently an almost indeterminate chord, with the possible inclusion of a predominant note. In short, when the blades of a propeller are semi-resonant, they are more selective in relation to the frequency of breakdown of cavitation bubbles which produce resonant vibration, and the emission of noise becomes dependent upon the varying conditions that occur.

If a blade of a propeller is struck at any point on its surface, the sound emitted may bear no definite connection to the natural frequency of the blade, if such exists, due to the fact that intense forced vibration is set up over a local area. It is safe to assume that the hydrodynamic disturbing forces to which a blade is subjected are not severely local, as they are caused by the breakdown of a series of bubbles, set up at the blade edge, impinging on an area of varying shape and location, depending upon the blade section and the speed through the water. This hydrodynamic effect may be simulated by striking a blade edge gently with a block of wood, the point of application being varied up and down the length of the blade. If the blade is of appropriate form, it will be found that the note resonated will not vary greatly in pitch as the point of impact is moved along the length of the blade, attention being limited to about two-thirds of the blade length. This constancy of pitch suggests that the blade is liable to emit noise in service.

Similar experiments with blades known to be silent in service show that the note sounded may vary considerably round the blade, and special reference may here be made to the Admiralty type of wide-tip propellers, which are all silent. In the course of the first experiment, it can also be observed that both the edge that is being struck and the opposite edge are maintained in a state of vibration, although the centre of the blade remains motionless, thus indicating that the blade is vibrating just in the way that a butterfly flaps its wings. It may be inferred, therefore, that the small exciting forces at the blade edges, caused by the breakdown of cavitational bubbles, produce this type of vibration, hereafter referred to as "lateral," in which opposing blade edges vibrate in unison, forming a stationary nodal line down the region of the blade centre. This nodal line may extend to the tip of the blade, thus completely separating the vibrating halves by a stationary ridge, as in Fig. 1 (*a*), herewith; or, alternatively, depending upon the shape and thickness of the blade, the nodal ridge may wash away towards the tip, thus allowing the latter to rise and fall together, with each side forming a cup-shaped tip at the maximum amplitude of vibration, as in Fig. 1 (*b*). This type of tip vibration will hereafter be referred to as "disc vibration," since, in effect, the tip in these circumstances vibrates as part of a disc held rigidly at its centre. It should be noted that disc vibration can only occur in conjunction with lateral vibration, and, as it is susceptible to a greater degree of damping, its occurrence is more unusual.

In order to analyse in greater detail the character of lateral vibration, it will be convenient to divide the blade under discussion into a series of thin strips by lines drawn at right angles to the nodal line, as in Fig. 2 (*a*). If one such strip is considered as being separated from its neighbours, suspended in space, and set in a state of lateral vibration causing a nodal line to appear near its centre, it is apparent that the frequency of vibration must be identical for the leading and trailing portions of the strip, and that the actual position of the nodal line will be central if the section is symmetrical, and offset towards the trailing edge if the section is aerofoil. Vibration of a particular strip, in the form referred to, will only be set up if its immediate neighbours, when considered independently, vibrate at the same frequency. If successive strips have similar frequencies, so that a considerable radial length is tuned, one side with respect to the other, the blade will be resonant and small periodic forces at the edges will have the effect of setting up lateral vibration of this length of the blade. The strips towards the root of a blade always have a higher frequency than strips included in, say, the outer two-thirds of its length, depending upon its actual shape, owing to the increasing thickness at the root in association with the decreasing width of section, and hence the root always acts as a damping factor to lateral vibration. It is, therefore, in the outer two-thirds of the blade length that a constant frequency may be looked for, and its occurrence will depend entirely upon blade thickness in conjunction with blade width. Incidentally, it may be shown mathematically that this outer two-thirds of the blade length is, in general, of such a geometric form as to comply fairly readily with the lateral-resonance requirement that the natural frequency of successive strips across the blade should be constant. This accounts for the repeated occurrence of propellers that sing. If the constant frequency extends to the tip, with or without the occurrence of disc vibration, the blade will be resonant; if, on the other hand, the uniformity of frequency extends over only a limited length of the blade, the tip being out of harmony and thus providing additional damping, the blade will be semi-resonant, possessing the properties already mentioned. An entire absence of constancy of frequency over any longitudinal length indicates non-resonance of the blade.





The foregoing description of lateral vibration entirely neglects the possibility of the imaginary sectional strips being tapered, instead of parallel, as exemplified by Fig. 2 (*b*). The tapering of a section greatly alters its natural frequency, and, therefore, by the occurrence of a mutual adjustment between neighbouring imaginary strips, a length of blade may accommodate itself into a tuned condition, forming a complex vibrational system which is indeterminate by direct methods of calculation. For purposes of analysis the problem may be conveniently approached by an analogy which produces a pictorial result, conveying a comprehensive impression of the vibrational qualities of the blade.

Take a specimen lateral strip from a blade, and let it be imagined that it is gripped in a vice so that the leading part of the section is protruding from the jaws to such a degree that it has a lateral vibrational frequency of, say, 200 vibrations per second. A line could be marked on the blade section where it is effectively held rigid by the vice, and that line could be labelled 200. The blade section could be re-arranged in the vice so that a greater leading part of the section was protruding, having a frequency of only 150 vibrations per second, and a corresponding line of 150 could be scribed. Similarly, the 100 line could be found, and by reversing the blade section in the vice the trailing part could be dealt with in the same manner. If it were then seen that the lines respresenting 150 vibrations per second for the leading and trailing edges were coincident, it could be said that the strip would have a lateral frequency of 150 vibrations per second when unsupported, since the natural stationary nodal point would correspond in position with coincident imaginary vice-jaws appropriate to each edge.

If a series of strips at intermittent points along the length of the blade were dealt with in this manner, and the respective 100, 150 and 200 independent nodal lines, corresponding to the leading and trailing edges, respectively, were developed into a series of six curves on the plan view of the blade, the resulting diagram

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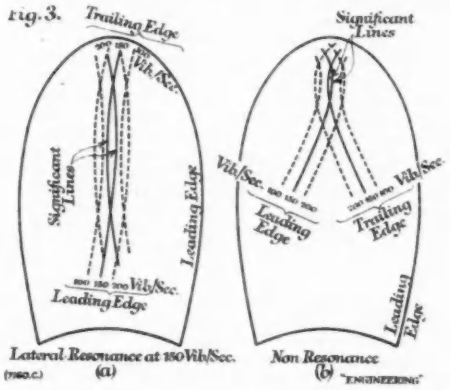
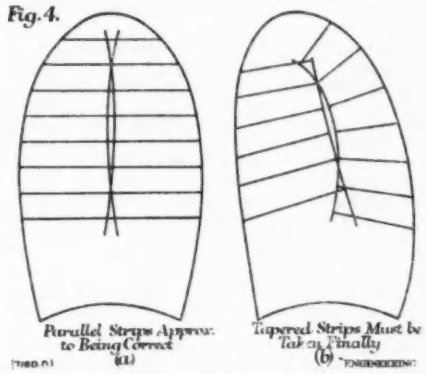
* Paper read at a meeting of the Institution of Engineers and Shipbuilders in Scotland, held in Glasgow on November 21, 1939. Abridged.

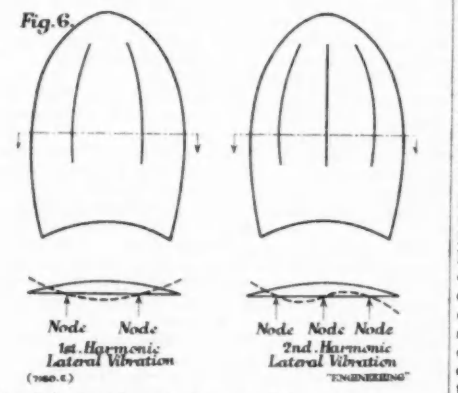
† *Trans. I.E.S.*, vol. 82, page 256 (1938-39).

would show nodal locus lines for 100, 150 and 200 vibrations per second for the trailing and leading blade edges, as shown in Fig. 3, herewith. Attention should now be directed to the pair of nodal lines of the same frequency, leading and trailing, which become most nearly tangential to one another if greatly curved, or are most nearly coincident over a part of their length if only slightly curved. This pair may be referred to as the "significant nodal lines." Lines corresponding to other frequencies, having served their purpose, can now be discarded. It now becomes evident that the length of the blade over which the significant nodal lines are approximately coincident has a nearly constant lateral vibrational frequency, and this corresponds with the frequency for which this particular pair of lines was calculated. If the approximate coincidence covers a considerable proportion of the outer two-thirds of the length of the blade, then the blade is resonant, Fig. 3 (*a*); a short length of approximate coincidence will render the blade semi-resonant. An absence of coincidence amounting to tangentiality of the significant nodal lines infers absolute non-resonance, Fig. 3 (*b*), although this statement is qualified at a later stage.

The actual nodal line will tend to form at the mean position indicated by the independent nodal lines for the leading and trailing edges, over the length that these may be approximately coincident. In using the term "approximately coincident," recognition is made of the mutual adjustment that will occur between adjacent imaginary sections in actual lateral vibration, as already mentioned, resulting in a vibrational form such as is shown in Fig. 2 (*b*). From an entirely different aspect, approximate coincidence must be associated with the practical inaccuracies occurring in the manufacture of a blade, together with the approximations which must attend the frequency calculations.







The occurrence of taper in the plan view of imaginary strips shows that the vibration analysis of a blade is not practicable in a direct manner. The independent nodal-line analogy takes account of the potential tapering of imaginary sections, when due regard is paid to maintaining the dividing lines between strips at right angles to the nodal line, as explained in the following way: Assume for the moment that the significant nodal line corresponding to the leading edge of a blade has already been found correctly, and that the blade is gripped in a large vice, the jaws of which are shaped so as to hold the blade along the nodal line with the leading edge protruding. If the nodal line were more or less straight, Fig. 4 (*a*), on this page, the leading edge would vibrate in the same manner as if it were a series of dissociated parallel strips. If, on the other hand, the significant nodal line is well rounded, Fig. 4 (*b*), the leading edge will vibrate approximately as if it were a series of dissociated segments or tapered strips in plan view. Vibration about a nodal line, therefore, must be considered in relation to specimen segments formed by a series of lines drawn at right angles to the nodal line. A strip that is tapered in plan, so that the width at the blade edge is greater than the width at the node, has a lower vibrational speed than the corresponding parallel strip. Consequently, the actual position which a nodal line of any frequency assumes on a blade surface is dependent also on its curvature, which, naturally, is not known when its position is being calculated in the first instance. This necessitates a certain amount of trial and error in the calculation, the assumption first of all being made that the nodal line will be straight and a subsequent calculation being made to allow for any degree of taper that may be caused by the occurrence of curvature.

When a disc of suitable material and dimensions—for example, a cymbal—is held at its centre and struck, it will vibrate in resonance because of its circumferential uniformity. The tip of a propeller blade may, in some circumstances, be pictured as half a disc which may vibrate about its nodal centre in conjunction with, and at the same frequency as, the lateral vibration of the neighbouring portion of the blade. An approximation may be made to the vibrational frequency of a cymbal from a consideration of a radial section, and, as all radial sections are identical, the same result will be obtained whichever one is chosen. In the case of a propeller-blade tip, assuming that the central node of a disc vibration has been ascertained, it is highly improbable that calculations based upon the shapes of a series of radial lines from this centre to the blade tip and edges, through a semi-circle, will show the same frequency in each case. A small variation in the frequency of radial sections round the semi-circle will allow resonant vibration to occur by means of mutual accommodation of the segments. A large discrepancy in radial frequencies round the semi-circle will considerably damp any vibration and will ultimately eliminate it. In view of this radial variation, the choice of the central node of vibration must be to a certain degree nominal. It is apparent, however, that such vibration will only occur when prompted by and associated with lateral vibration, and consequently the nodal centre must lie at the outer extremity of the lateral nodal line, that is, centrally between the independent nodal lines for the lateral vibration. Further, if the nominal choice is made that the nodal centre is at such a distance from the blade tip that the disc frequency calculated on the radial line drawn to the tip is the same as the lateral frequency, then the position of the central node is fixed. The susceptibility towards disc vibration will then depend upon the resemblance to the lateral frequency of frequencies as calculated on diagonal lines from the nodal centre to the leading and trailing edges adjacent to the tip, and furthermore upon the actual position of the centre.

Due to secondary bending effects, a disc derives rigidity from a source which is denied to the plain strip under deflection, with the result that the vibrational frequency of a disc is of a higher order. As the lateral type of vibration breaks off into disc vibration in rounding the tip, there is a gradual and incalculable change of character in the deformation of the material. Recognition of this fact has been made in the analysis of propeller blades by taking the lateral vibration as supreme, up to and including the radial lines which bound the tip semi-circle, and no disc-frequency calculation is made on any radial line for an angle of at least 30 deg. to the boundaries. The form of the frequency curve is assumed to take sufficient cognisance of this aspect.

If the relative position of the nodal centre occurs at the outer extremity of the range of approximate coincidence of the nodal lines, it is in its most advantageous position to promote disc vibration of the tip, because where the lateral vibration is commencing to diminish, the disc form picks up and carries the vibrational waves round the tip in cup-shaped form. If, on the other hand, the disc nodal centre falls at the middle or towards the inner extremity of the range of approximate coincidence of the independent nodal lines, the tip is presented with the alternative of vibrating laterally or in disc form. In such circumstances it is highly improbable that the latter type would assert itself, because vibration of disc form absorbs more energy than lateral vibration, and also because disc-form resonance, by reason of its nature, tends to be less nearly perfect than lateral resonance.

It should be emphasised that the existence of good resonant qualities in a propeller blade does not indicate the circumstances in which the blade may sing at sea, or even indicate that it will emit noise at all, but it may be said that the more resonant a blade is, the more likelihood there is of its singing under a wider range of conditions. On the other hand, except in circumstances of complex resonance, a blade of non-resonant form will not sing. To be assured of silent performance, it is necessary to design for absolute non-resonance, as otherwise the risk is incurred of quite a small discrepancy in manufacture rendering some or all of the blades resonant to a degree that may involve noise in service.

The foregoing description of a lateral vibrational system in a propeller blade is based on the existence of a single nodal line down the region of the blade centre, and as such it may be termed "fundamental lateral vibration." Examination of records of the predominant notes emitted by certain resonant propellers shows, however, that these notes do not always correspond to the fundamental natural lateral frequency of the blades, but are sometimes about an octave, or an octave and a half, higher than that fundamental frequency. This has been found to occur only with propeller blades having a low fundamental frequency, about 150 vibrations per second or less, and the inference is that the range of frequency of the disturbing forces at the blade edges is higher (150 to 300, as already mentioned) than the fundamental blade frequency and, therefore, incites harmonic vibration in the blade, of the first or second order, with two or three nodal lines down the blade length, as in Fig. 6, herewith. There is little question of the occurrence of disc vibration of the tip in such circumstances.

In a piano wire, the first harmonic corresponds to twice the fundamental frequency, being one octave higher, and the second harmonic is three times the fundamental frequency, being one and a half octaves higher. In a parabolic section this is not exactly the case, the harmonic multipliers being somewhat higher than 2 and 3, respectively, depending upon the precise cross section of the blade and the degree of curvature of the nodal line, etc. It is quite impracticable to make a direct analysis of the harmonic orders of vibration that may occur in a propeller blade. On account of the fact, however, that the harmonic frequency multipliers are more or less constant for varying proportions of parabolic sections, a blade can only be laterally resonant with respect to the higher harmonics when it is resonant, at least to a certain degree, for the fundamental system. On the other hand, it should be noted that a fundamentally semi-resonant blade may be particularly prone to harmonic vibration, on account of the increased scope for mutual accommodation of the imaginary strips referred to above. In design it is sufficient to ensure that the blade is fundamentally non-resonant.

Complex resonance may be said to occur when, by means of mutual adjustment between neighbouring imaginary strips in lateral vibration, a length of blade with a low natural frequency is co-ordinated with adjacent lengths of blade having a higher natural frequency to form a resonant system with a mean frequency. A vibrational form of this type involves greater distortion of the blade than simple lateral vibration, and, in consequence, the damping is greater and the resonance less pronounced. This complex resonance is a result of the simple lateral frequency of individual strips falling to a minimum value towards the mid-length of the blade; if this frequency fell to a minimum at the blade tip there would be no scope for complex mutual accommodation of strips, and, incidentally, the independent nodal lines would then only interest each other once. Although such an ideal state is unattainable, due to the rounding off of the propeller tip with a resulting increase in lateral frequency towards the tip, it is possible to arrange for the minimum lateral frequency to fall, say, within the outer quarter of the blade length, so that the blade is allowed insufficient scope to enable effective complex vibration to arise. This means that, for non-resonance, with freedom from the possibility of complex resonance, the significant nodal lines should be non-coincident, forming a loop with each other within the outer quarter of the blade length.

In order that the full significance of the processes of the elimination of propeller-blade resonance may be appreciated, it is necessary that the principles should be understood by which an increase or decrease of frequency may be effected on a given section in lateral vibration. To increase the frequency of the section

the general rule applies that the vibrating mass must be reduced, the greatest effect being produced by reductions farthest from the node. Alternatively, the same result may be obtained by increasing the rigidity of the section, the greatest effect in this instance being produced by appropriate modifications adjacent to the node. The converse is also true. This means that, while a reduction of thickness adjacent to the blade centre has the effect of reducing the frequency, a reduction in thickness towards the edge or a reduction in width has the reverse effect. As a guiding rule, it may be taken approximately that a point half way between the node and the edge provides the boundary for these opposing conditions, and that consequently a reduction in thickness in the inner half reduces the frequency, and, in the outer half, increases it.

The avoidance of resonance involves the manipulation of widths in conjunction with thickness, in order that the natural lateral frequency may vary appreciably along the length of the blade. From the aspect of the independent nodal-lines analogy, the aim is to obtain a diagram in which the nodal lines are non-coincident and form a loop, preferably near the tip, which means that the lateral frequency must be at a minimum where the loop occurs. Individual mention should be made, firstly, of the conditions that arise when remedying singing in an existing propeller, and, secondly, when preventive measures are being taken in the design of a new propeller. In the elimination of existing resonance it is doubtful whether attention should be paid to the avoidance of possible complex resonance, since to do so would be to entail, in most cases, a more extensive and costlier alteration to the blades; it has been stated that available data show the improbability of vibration being set up in this manner.

In the design of a new propeller there is greater scope for suitable adjustments, in that thicknesses and widths may be increased as necessary. In these circumstances it is desirable to avoid risks of complex resonance. The primary design of the propeller should be completed in accordance with the individual designer's requirements as to efficiency, etc., and it will then be found that only comparatively small changes are required to destroy resonance, if calculations should show that this is present. It will frequently be found that the initial occurrence of resonance is minimised if the taper of the back of the blade is broken at about one-quarter of the blade length from the tip, so that the outer quarter has less taper in thickness than the remainder of the blade.

Certain well-known characteristic features are displayed in one form or another by many noisy propellers, and the following theories are put forward as fitting in with observed facts:

Variations of Pitch of Note with Speed.—The greater proportion of noisy propellers emit a note of constant pitch in all the conditions in which noise occurs, a fact that fits in simply with the theory of lateral vibration. Cases occur, however, in which there is a variation of pitch corresponding to a variation of speed of the propeller. It is possible that this may be caused by a movement in the position along the blade edge of the sympathetic bubble disturbance, which, in a semi-resonant blade, could have the effect of causing a mutual readjustment between adjacent imaginary sections, thus producing a slightly modified pitch in the note emitted. On the other hand, the sudden change of a note through an octave or half an octave indicates a change to a different order of harmonic vibration, as induced by differing hydrodynamic conditions with change of speed.

Variation of Pitch of Note during each Revolution.—When a change of note is heard during each revolution, it immediately suggests that only one propeller blade is responsible for the noise, otherwise the combined effect of each blade producing the same variation would be a more or less constant chord. Such variation of pitch could be caused as described in the last paragraph, the varying hydrodynamic conditions in this instance being caused by the variation in the wake stream experienced by the blade during a revolution.

Louder Note with Increased Immersion.—It appears to be a definite rule that, when a propeller sings on a lightly loaded ship, the noise will be louder when the draught is increased. Bearing in mind the greater effectiveness of water compared with air as a medium for the transmission of sound, it is probable that this characteristic may be explained by the fact that, with a more deeply loaded ship, a greater area of immersed hull is presented for the reception of the sound waves that are transmitted wholly through the water, resulting in an apparent increase of the noise from the propeller.

New Ships with Propeller Noise which Diminishes.—When a new vessel goes out on trial it is sometimes noticed that the propeller sings at first, but that after some hours the noise diminishes or possibly completely disappears. This feature is probably demonstrated by propellers of the semi-resonant type, in which the hydrodynamic forces at the blade edge are of insufficient magnitude to induce resonant vibration within the working range of conditions, but in which the exciting vibratory forces emanate from the propeller shaft due to excessive initial friction on the end wood of the stern bush.

Propellers which Grunt.—Many instances are recorded of propellers which emit what must be described as a grunting or grinding sound of low frequency. In such cases true singing may be detected, either together with the grunting or under different conditions of running, although the true note so emitted may be faint. It is suggested that the grunt is possibly caused by the low-frequency beats produced in each revolution when two blades pass successively into the wake stream and are set vibrating with slightly different frequencies, the beats being the periodic amplification and nullification of the sound waves of different length. This phenomenon is made use of in the *vox humana* stop of the organ, and can be easily demonstrated by two people whistling sustained notes of slightly differing pitch.

The cause of two blades vibrating with different frequencies may be due either to small discrepancies between the finished widths and thicknesses of successive blades, or, alternatively, to a slight variation in the pitch of the note emitted by each blade during a revolution. In view of the fact that water is a more effective medium than air for the transmission of sound, and considering the pronounced effect of beats as produced in the air, it is a reasonable assumption that, if beats are produced in water and transmitted to the hull of a ship, the audible effect will be appreciable. Further, because of the practical difficulties of manufacture attending the precise repetition of a series of propeller blades, it is certain that a proportion of completed propellers possess blades, a pair of which have lateral frequencies capable of producing beats when set in vibration. The author is unaware of a characteristic sound from any noisy propeller being associated with beats, and it is this combination of facts which seems to point to the theory that grunting may be due to the cause suggested.

BENCH-TYPE TABLE SURFACE-GRINDING MACHINE.

THE bench-type surface-grinding machine illustrated in Figs. 1 and 2, on this page, is of the table type, that is, the work is supported on a flat table above the surface of which the grinding wheel projects slightly. The wheel is of the ring type, 8 in. in external diameter, and the centre is filled in with a circular plate to make the table surface continuous. The extent of the grinding surface is best seen in the external view Fig. 1, the major part of the periphery of the wheel being available. The back portion of the table is occupied by a cover, the front part of which forms a fence, and which also supports the central plate. The construction of the machine will be clear from the sectional view, Fig. 2. The grinding wheel *a* is cemented to a steel carrier plate *b* of standardised design and dimensions, the plate being attached by set screws to the disc *c* mounted on the spindle of the driving motor. The rotor is indicated at *d* and it will be noted that the spindle is supported at the top, immediately under the disc, in roller bearings and is carried at the bottom in ball thrust bearings. The motor has a capacity of 1 h.p., and is of the squirrel-cage type running at a speed of between 2,850 r.p.m. and 3,000 r.p.m. Three different windings are available, viz., either 400/440 volts, three-phase, 50 cycles, 200/400 volts, two-phase, 50 cycles, or 200/250 volts, single-phase, 50 cycles. It is totally-enclosed and dustproof.

The motor windings are carried in the base *e* of the machine, the upper part of which is machined to form a cylindrical sliding way for the table casting *f*. This casting rests on a circular nut *g*, with capstan turning levers, screwed on the base casting. As shown, this nut is in its highest position, the table being thus adjusted to suit a new grinding wheel. As the wheel wears, the table is lowered as required by rotating the nut. Stops are provided to limit the table traverse and a lock to prevent its rotation. The cover *h*, which carries the upper bearing of the spindle and encloses the motor, is fitted with a flexible packing diaphragm, which provides an effective dust seal in any position of the table casting. To the underside of the disc *c* is attached a fan *i*. This rotates in a chamber formed below the table surface and having an outlet to which is attached a removable dust bag *j*. The front of the fence is formed with a number of slots, clearly seen in Fig. 2, and these slots communicate, through holes in the table top under the cover, with the fan chamber. Since the fan draws air through these holes and slots, it follows that the dust, as it is formed on the surface of the wheel or table, is immediately drawn into the fan chamber, from which it is discharged into, and intercepted by, the bag, thus complying with the requirements of the Factory Act, 1937. The wheel has a useful wearing limit of $\frac{3}{4}$ in., and the carrier plate can readily be detached after the removal of the fence and cover, when it can be sent to the makers for renewal.

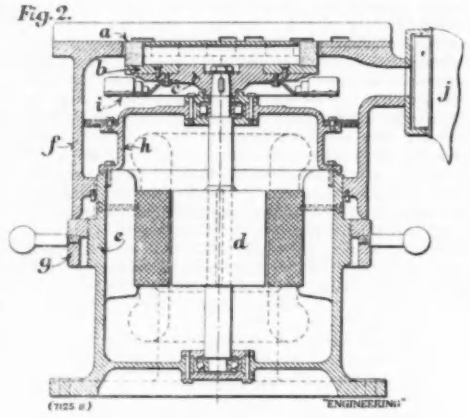
Control is by means of a quick-break "Arrow" switch enclosed in a dust-proof cast-iron case attached to the base casting, as shown in Fig. 1. The overall height of the machine is 15 in. and the outside diameter is 14 in. The weight is 200 lb., so that it can be easily moved from place to place. Alternatively, the machine can be supplied mounted on a cast-iron pedestal, when the height from the floor to the table surface is 2 ft. 10 in. This fitting has been designed primarily for toolroom use, but both types are likely to be of service in fitting shops, garages and so forth, for jobs which require to have a good finish, but in which a high degree of accuracy is not necessary. The makers of the machine are Messrs. Wright Electric Motors (Halifax), Limited, Century Works, Pellon-lane, Halifax.

TABLE-TYPE SURFACE-GRINDING MACHINE.

MESSRS. WRIGHT ELECTRIC MOTORS (HALIFAX), LIMITED, HALIFAX.

FIG. 1.

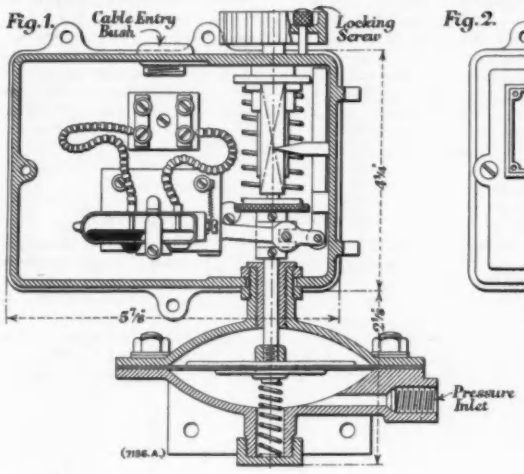
Fig. 2.

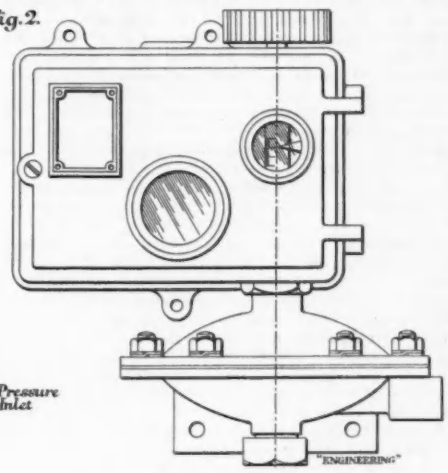


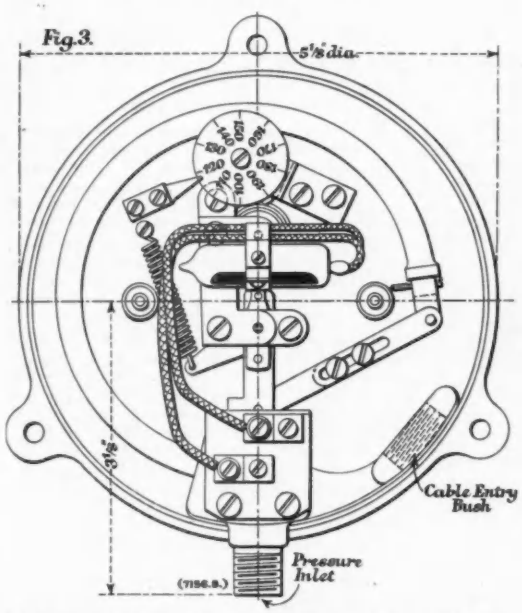
SWITCH-TRANSFORMER UNIT FOR LOW-VOLTAGE CIRCUITS.—In recent years the campaign for greater safety in factories has resulted in the installation of low-voltage lighting equipment in such places as boiler-houses and garages, as well as on machine tools. More recently still, similar apparatus has been installed in A.R.P. shelters. A useful component in connection with such circuits is the switch-transformer unit, which is manufactured by Messrs. The General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2. This consists of a 150-watt transformer, the primary side of which is designed for connection to a single-phase, 50-cycle circuit, while the secondary is wound for either 12 volts or 25 volts. In addition, there is a double-pole switch and fuses on the primary side and double-pole fuses on the secondary. The transformer is double wound, the centre point of the secondary being earthed. The complete unit is housed in an iron-clad case.

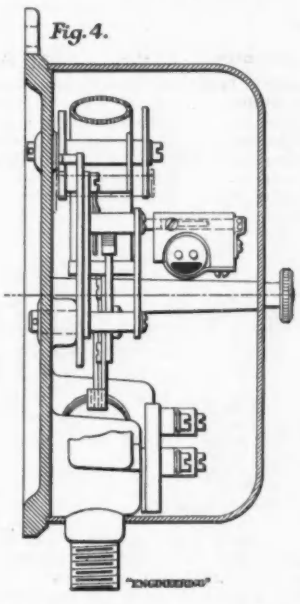
PRESSURE-OPERATED CONTROL SWITCHES.

MESSRS. THE BRITISH THERMOSTAT COMPANY, LIMITED, SUNBURY-ON-THAMES.









PRESSURE-OPERATED CONTROLS FOR ELECTRICAL APPARATUS.

THE modern boiler house depends, to a great extent, for its smooth working on electrically-operated equipment, such as mechanical stokers, induced-draught and forced-draught fans, magnetically-operated valves, and dampers actuated by servomotors. All such equipment is required to assist in maintaining a steady boiler pressure, and, it is clear, that in most cases it can only be regulated effectively by automatic means. One such means is provided by the pressure-operated switches manufactured by Messrs. The British Thermostat Company, Limited, Sunbury-on-Thames, Middlesex, two recent types of which are illustrated in Figs. 1 to 4, on this page. Although boiler-house equipment has been specifically referred to above, it will be understood that the switches operate equally well with water, air or gas pressure as with steam pressure, and, in consequence, can be employed for other purposes than those particularised. Generally, they are arranged to interrupt the electrical circuit when the applied pressure rises above a predetermined value, but, alternatively, the switches can be supplied to close a circuit on increase of pressure, and also with change-over contacts for two-circuit control.

The two types here illustrated are designed to work with low and high pressures, *i.e.*, pressures of the order of a few inches water gauge and pressures in excess of 100 lb. per square inch, respectively, but another type is made which operates at intermediate pressures. The very low pressure type, identified as Model K. 16, is shown in the external view, Fig. 2, and the section, Fig. 1. The pressure element consists of a spring-balanced diaphragm housed in a chamber attached to the switch case and the switch operated from it is a tilting non-oxidising mercury tube. The case, which is of die-cast metal, is dustproof and moisture-proof, and has a hinged cover provided with two windows, through one of which the switch itself is visible, while the other shows a fixed scale having a pointer indicating the pressure at which the instrument is set. As shown in Fig. 1, the switch is level and the circuit is closed. A rise of pressure giving an increase of pressure in the chamber below the diaphragm, will cause the diaphragm spindle to move upwards, thus tilting the switch and opening the circuit. The switch is rated to break 15 amperes at 250 volts, either alternating current or direct current. With a voltage of 440, it is rated to break 10 amperes alternating current or 5 amperes direct current. Large plants should be controlled through contactors actuated by the instrument, but it can be used for the direct switching of motors up to 1·25 h.p. single-phase alternating current, or up to 0·75 h.p. direct current, both at 250 volts. The standard pressure range is from zero to 10 in. water gauge and the differential is 3 in. water gauge. The setting to operate at any desired pressure within the range given is effected by turning the large knurled knob on the top of the casing, seen at the right-hand in both illustrations. The movement of this knob varies the compression of the spring round the diaphragm spindle, which spring, as it opposes the diaphragm load, determines the operating pressure. The knob is locked in position by a small screw, which itself can be locked by a wire through the head.

The construction of the high-pressure switch is shown in Figs. 3 and 4, from which it will be clear that the pressure element is a Bourdon tube, the free end of which is connected by a link system to a tilting mercury switch with the electrical leads sealed in one end. The switch is rated to control a maximum of 5 amperes alternating current or 3 amperes direct current, at up to 250 volts. On higher voltages or heavier loads the instrument must be used in conjunction with a relay or contactor. As illustrated, it is arranged to break circuit on a rise of pressure. The instrument is identified as Model F Z, and is made in three standard pressure ranges, each covering 100 lb. per square inch: thus, the lowest range is from 50 lb. to 150 lb. per square inch, and the highest from 150 lb. to 250 lb. per square inch. The pressure setting is indicated by the position of the small dial seen at the top of Fig. 3 relatively to a fixed pointer. This dial is not visible under working conditions as the whole mechanism is covered by a circular pressed-brass cover without windows. This cover is attached to the back plate by two studs and screws, provision being made for sealing against unauthorised interference with the setting. The cable entry is at the side and is bushed. The internal terminals are attached to the pressure-inlet connection and are Bakelite-shrouded.

This instrument has been developed for applications in which a fine differential, *i.e.*, the difference between the cut-in and cut-out pressures, is required. The range of adjustment of the differential is from 5 lb. to 15 lb. per square inch. The Bourdon tube and linked-switch system provide a comparatively large movement for a small change of pressure which gives a very fine working differential. Such a characteristic is of advantage in steam-boiler installations for such work as central heating and processing, in which installations the inherent "over-run" often greatly increases the overall differential of the complete system. This suitability for a particular service, however, does not imply that the switch cannot be used for the control of boiler auxiliaries of the types mentioned above.

CATALOGUES.

Fire-Service Equipment.—Messrs. Glenfield and Kennedy, Limited, Kilmarnock, have issued a catalogue describing hydrants and other fire-fighting fittings, in which they specialise.

Motor-Headlamp Masks.—Messrs. Trico-Folberth, Limited, Great West-road, Brentford, London, have sent us a leaflet describing their officially-approved headlamp masks, designed to provide the maximum illumination within the regulation limits.

Blast-Furnace Tuyeres.—Messrs. Ashmore, Benson, Pease and Company, Limited, Parkfield Works, Stockton-on-Tees, have sent us a descriptive leaflet of the Beaton tuyeres which they supply for use in blast-furnaces where difficulty is experienced with ordinary tuyeres.

Automatic Circuit Breakers.—We have received from Messrs. The General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, a new edition of their catalogue section dealing with all types of automatic circuit breakers for power and lighting services up to 660 volts.

Tool Steels.—Messrs. Darwins, Limited, Fitzwilliam Works, Sheffield, have sent us a pamphlet entitled "Cobaltcrom," and giving particulars of their air-hardening steels. The outstanding characteristic of this steel is its ability to harden in air evenly throughout, irrespective of variations in cross section.

Dust Removal and Collection.—Messrs. Davidson and Company, Limited, Sirocco Engineering Works, Belfast, have issued a brochure describing their range of "Sirocco" equipment, as applied to various industrial undertakings, for dust removal and collection. Some typical installations are illustrated and described.

Pumps and Presses.—We have received from Messrs. Charles E. Douglas and Company, Limited, 206-8, Cecil Chambers, 76, Strand, London, W.C.2, a catalogue describing the Ollaulic pumps and presses, constructed by Messrs. John Mills and Company (Llanidloes), Limited, for which they are the sales representatives for London and the Home Counties, and overseas. These pumps are of the high-speed, multi-ram type, and are designed to work at pressures up to 3 tons per square inch.

Diesel Engines and Electrical Plant.—We have received from Messrs. English Electric Company, Limited, Queen's House, Kingsway, London, W.C.2, a folder giving particulars of the Diesel engines made at their Willans Works, Rugby, including a 3,500 brake horse-power generating set; and also leaflets relating to isolated air-cooled transformers for machine-tool lighting, synchronous induction motors, fuse switches and safety handlamps.

THE LIFE-BOAT SERVICE IN 1939.—The Royal National Life-Boat Institution informs us that life-boats were launched more often in 1939 and more lives were rescued from shipwreck round our coasts than ever before in the history of the life-boat service. Life-boats were launched 677 times during the year, and 1,356 persons were rescued. The previous largest number of launches was 435, in 1938, and the previous largest number of lives rescued was 1,348, in 1917.

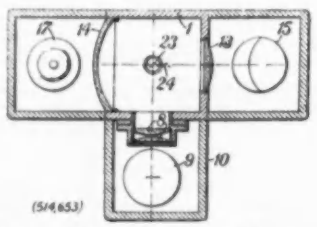
"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.
Where inventions are communicated from abroad, the Names, etc., of the communicators are given in italics.
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

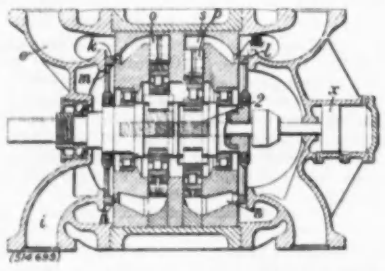
514,653. Smoke Detector. British Electricon (London), Limited of London, W. A. Robinson, and W. A. Chambers, of London. (3 *Figs.*) May 12, 1938.—The invention is an optical system for detectors operating on the "dark cell" or "quiescent" principle. The system is designed so that the light transfer due to diffraction or diffusion by smoke particles present in the air under examination, reaches a high value and ensures extreme sensitivity in operation. Air for examination is passed through a dark examination chamber 1, the front wall of which has an opening in which is fitted a lens system 8. Behind this system an electric lamp 9, having a linear filament,



is housed in a casing 10 attached to the examination chamber. The side walls of the chamber 1 have openings, a lens 13 being fitted in the one opening and a spherical reflector 14 in the other. The reflector is a Mangin mirror silvered on the outer face and having its front and rear faces of different radii of curvature to compensate for refraction. A photo-electric cell 15 is mounted in a dark casing in front of the lens 13, a valve 17 being provided to amplify the output from the cell. The casings for the cell and the valve are hinged to the examination chamber 1, so that they can be opened when the cell and amplifier require attention. The optical axis of the lens system 8 intersects the optical axis of the spherical reflector at its focal point 23, and the lens system 8 projects a latent image 24 of the lamp filament on to the axis of the reflector at this point. When smoke is present in the air flowing through the examination chamber, the particles reflect the light from the lamp which renders the latent image of the filament luminous, and light from this luminous image is directed by the spherical reflector as a beam through the lens 13, which focuses it on to the cell 15. The cell output, amplified by the valve 17, energises the alarm circuit.—(*Accepted November* 14, 1939.)

HYDRAULIC APPARATUS.

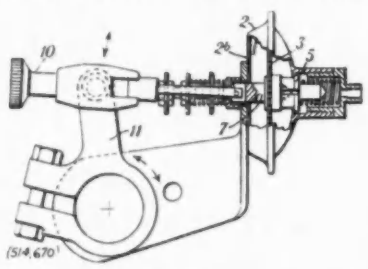
514,699. Hydraulic Transmission. Newton Brothers (Derby), Limited, of Derby, F. Newton, of Derby, and R. C. Roe, of Rochdale. (4 *Figs.*) May 13, 1938.—The invention is a pump and motor unit of the type in which rollers are carried on eccentrics on the main shaft. The pump and motor units are identical and are coupled by



a common hydraulic circuit. On the shaft of each unit are eccentrics carrying valve rings *k* and *l*, which move over two series of ports *m* and *n* at different radii. Two series of rollers *o* and *p* are carried upon eccentrics of adjustable eccentricity and as the shaft rotates they move in and out in pockets *s* in a stationary casing, varying the volumes of the pockets and of the spaces between the rollers. The ports *m* and *n* communicate with the pockets *s* and the spaces between the rollers, respectively. Oil is drawn from the intake ports *i* at the ends of the casing past the inner edges of the valve rings *k* and *l* to the pockets and spaces, then, as the fixed and adjustable eccentrics move round, it is expelled past the valve rings *k* and *l* to the outlet ports *e*. The adjustment of the eccentrics is effected hydraulically by a piston *x*. The piston rod is located in a slotted and flattened portion of the shaft and carries, on opposite sides at different parts of its length, slanting splines 2 engaging in corresponding grooves in two pairs of cheek pieces, each pair lying one on each side of the shaft and piston rod and filling the spaces between these parts and the eccentric rings. The throws of the eccentrics are set at 180 deg. to each other, and the sets of splines are so arranged that movement of the piston and piston rod to the right simultaneously reduces the throw of both eccentrics. The eccentrics of both pump and motor are under the control of the same hydraulic control valve. This valve has three positions: in the first, the motor eccentrics are at maximum throw and the pump eccentrics at minimum throw, and the motor remains stationary. In the second position, the eccentrics of both pump and motor units are set at their maximum throw; the motor then runs at half speed. In the third position, the pump eccentrics are set to their maximum throw and the motor eccentrics to their minimum throw; the motor then runs at full speed. A given speed ratio is maintained by moving the control valve to a fourth position in which all the valves are closed so that the two pistons *x* are hydraulically locked in position. (*Accepted November* 15, 1939.)

INTERNAL-COMBUSTION ENGINES.

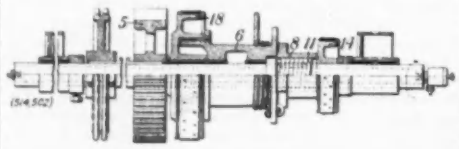
514,670. Timing of Supercharged Engines. F. H. Arnott, of Bushey Heath. (3 *Figs.*) February 2, 1938.—The invention is an automatic ignition-control mechanism for supercharged engines, which is responsive to the positive pressure built up in the induction. The apparatus consists of a box 2 in which is a flexible diaphragm 3. A member 5 is pressed against the inside of the diaphragm by a spring housed in a hollow nut connected to the induction pipe at a point between the supercharger



and the engine. The wall 2*b* of the box contains an opening so that the rear of the diaphragm is open to the atmosphere. Attached to the diaphragm is a rod 7 which passes through the wall 2*b* and is attached by a vernier knob 10 to an arm 11 which advances or retards the timing. The rod 7 is spring-loaded for part of its inward travel and the extremities of inward and outward travel are defined by adjustable stops. By arranging that the diaphragm abuts, in moving to the right, against a limit stop when atmospheric pressure obtains in the induction, the device is responsive to positive pressure only. (*Accepted November* 15, 1939.)

LIFTING AND HAULING APPLIANCES.

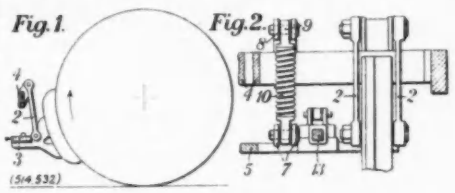
514,502. Hoist. Winget, Limited, of Rochester, and C. W. Stancliffe, of Rochester. (2 *Figs.*) May 7, 1938.—The invention is a hoist for raising and lowering the hopper of a concrete mixer. The shaft is rotated continuously by a motor and also drives the drum of the mixing machine through a gear 5. A winding drum 6 is mounted in bearings on the shaft and can be locked to it by an expanding coil clutch 8 operated by a friction



brake. The clutch housing surrounds the shaft and drives the drum 6 through teeth on the drum and the housing. Within the housing is a coil spring 11, one end of which abuts against a stop on the shaft. The other end of the spring abuts against a stop on a brake drum 14, which is driven from the shaft through the spring. When the drum 14 is retarded by a brake band, the spring 11 is expanded and contacts with the interior of the housing 8, clutching it to the shaft and rotating the winding drum 6. The winding drum is normally prevented from reverse rotation by a friction brake 18 connected to it through an expanding coil clutch. The brake drum is mounted free on the shaft and is normally held stationary, when the winding drum can rotate to wind on the cable. To unwind the cable the brake 18 is released and rotates with the drum 6. The hoist is thus controlled by applying the brake 14 to wind the cable and releasing the brake 18 to unwind it, and both these operations are controlled by a single handle. A system of springs between the handle and the brake bands ensures that if the operator should leave go of the handle during either raising or lowering, the drum 6 is disengaged from the shaft and held against reverse rotation. An interlock ensures release of the winding drum from the shaft when the hopper is fully raised and prevents engagement while it is in that position. (*Accepted November* 9, 1939.)

RAILWAYS AND TRAMWAYS.

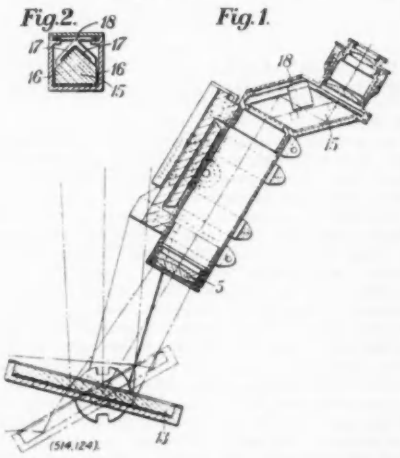
514,532. Railway-Brake Rigging. A. W. Maley, of Birmingham, and E. M. Taunton, of Birmingham. (5 *Figs.*) May 9, 1938.—The object of the invention is to prevent chattering of the shoes of railway brakes, by taking up all play in the brake-shoe suspension. Compression springs are arranged parallel with and beside the hanger 2, their thrust being applied to the brake beam 5 and truck cross-bar 4 at points on the axes of



the hanger pivots through brackets 7, 8 attached to the brake beam and cross-bar, respectively, and connected by a telescopic link 9, around which the compression spring 10 is wound. The attachment of the brake rod 13 to the brake beam is also on the level of the beam-link pivots to avoid any tilting action. The initial stress in the spring 10 is adjusted by a nut on the link 9 to a value which keeps the tangential force on the shoe always of the same sign. (*Accepted November* 10, 1939.)

MISCELLANEOUS.

514,124. Reflecting Telescope. Cooke, Troughton and Simms, Limited, of York, and E. W. Taylor, of York. (3 *Figs.*) April 27, 1938.—The invention is a reflecting telescope in which the image is erect. The bed-plate of the instrument has arms to which is pivoted the frame of a mirror 13. Between the objective 5 and its corresponding focusing eyepiece is a prism 15. The side elevation of this prism is a parallelogram with a 45-deg. angle and it has side walls 16 which are perpendicular to the base and top walls 17 which are chamfered at 45 deg. (Fig. 2). The prism 15 is mounted so that the light from the objective falls upon one of the internal surfaces of



the roof 17, and is internally reflected from the one roof wall to the other and finally to the base of the prism, and thence to the eyepiece. The prism is held in position by a V-shaped clamp 18. The end of the prism adjacent the eyepiece has a field stop-plate over it carrying fine cross wires. Since the external object being reflected is on the same side of the mirror as the telescope, the image will be inverted about one axis. The objective produces a further inversion and, additionally, a reversal as regards left and right, while the prism 15 produces a further reversal as regards left and right. Thus, the objective serves to correct the inversion due to the mirror and the prism corrects the reversal due to the objective, resulting in a totally-erect image. (*Accepted October* 31, 1939.)